IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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A. S. M. E. SPRING MEETING

ST. LOUIS, MAY 24 TO 27

MARCH 1920

PUBLISHED MONTHLY BY THE SOCIETY
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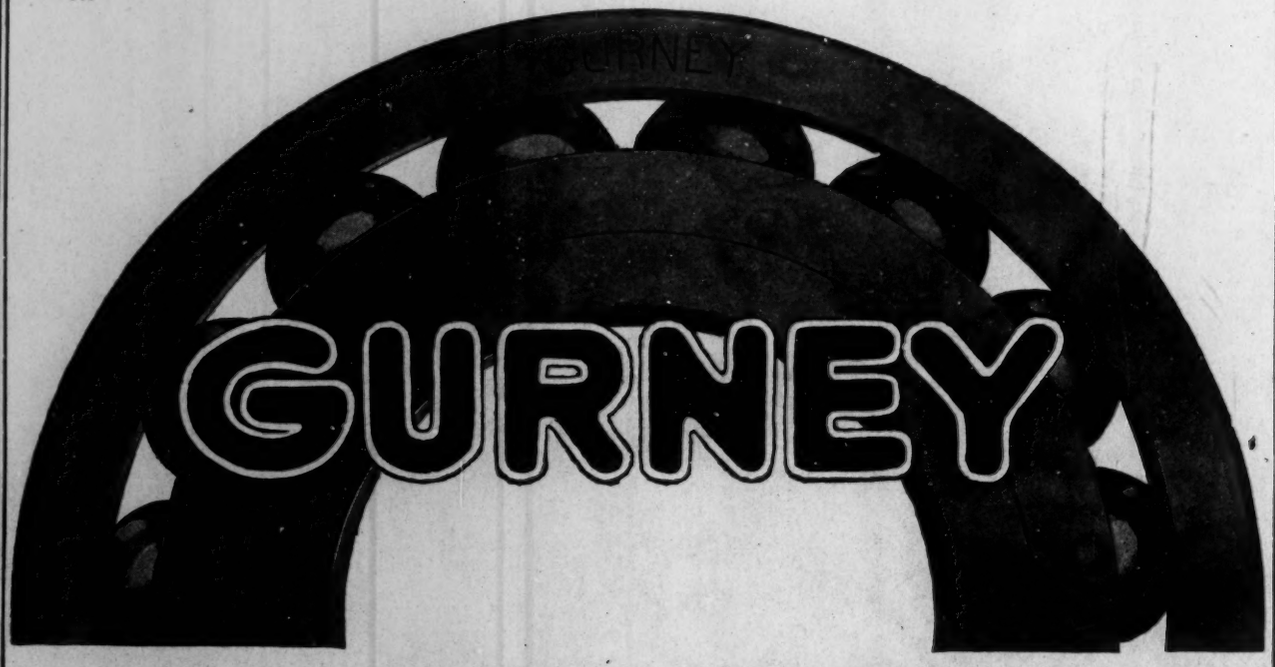

Mechanical Engineering

The Journal of The American Society of Mechanical Engineers

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Make Your Plans Now for the Spring Meeting of the A. S. M. E., to be Held at St. Louis, Mo., May 24-27

There will be a wide variety of papers presented at the St. Louis meeting of The American Society of Mechanical Engineers. These will include subjects such as Appraisal and Valuation, Industrial Housing, Airplane Development, Transportation on the Mississippi River, Engineering Accomplishments Resulting from the War, A Survey of Foundry Practice. There will be many single papers on technical subjects of interest to engineers generally. St. Louis has many attractions for visitors and because of its progressive spirit has become a great convention city. It likes to entertain guests and knows how to do it. You will like to be one of the guests and should not fail to reserve the dates of May 24–27 for attendance at this meeting. Headquarters will be at Hotel Statler.

Contributors and Contributions in This Number of Mechanical Engineering

Lieut. E. R. Jackson, Ordnance Dept., U. S. A.

Lieutenant Jackson was designated as Ordnance Observer with the Trans-Continental Motor Convoy of the Motor Transport Corps, U. S. Army, which left Washington, July 7, 1919, for San Francisco, via the Lincoln Highway. The convoy comprised 81 vehicles and trailers of various types and the trip was unique in that it was the first attempt to demonstrate a large number of loaded trucks over hundreds of miles of rough country. The trip was completed September 6, only five days later than schedule. Later Lieutenant Jackson rendered a technical report on the performances of the trucks, from which the leading article in this number was prepared and released by the Ordnance Department for publication in MECHANICAL ENGINEERING.

Prof. Allen H. Blaisdell, Carnegie Institute of Technology

A mathematical paper which received most favorable comment at the last Annual Meeting of the A.S.M.E. was that on Turbo-Compressor Calculations by Professor Blaisdell. It is also an important contribution in view of the growing prominence of centrifugal machinery and the demands for its use under higher pressures.

C. R. Weymouth Sends Contribution from the Pacific Coast

Up and down the whole Pacific Coast, both in North and South America, tall structures, such as chimneys, must be designed to withstand earthquake shocks. The firm with which Mr. Weymouth is connected has been in construction work for many years, and his article in this number on Self-Supporting Chimneys to Withstand Earthquakes puts on record many valuable data from a section of the country in which this subject is of paramount importance.

J. E. Sirrine Writes from the South

Still another section of the country is represented in the paper on Electric Power Supply by J. E. Sirrine, one of the leading consulting engineers of the South. This paper was secured by the Textile Committee of the A.S.M.E. for their session at the last Annual Meeting. The map which accompanies it shows the large extent to which electric power has been developed for the textile industry of the Southern States.

William F. Parish, formerly in Charge of Lubrication Department of the Government Air Service

The lubrication of the high-powered aviation motor was a problem of the first rank in connection with airplane development during the war. There was a shortage of castor oil and an investigation of mineral oils became necessary. Mr. Parish, who had had 20 years' experience as a lubrication engineer, was appointed at the head of a large department to take up the subject, and in a paper presented recently before the Chicago Section of the A.S.M.E., printed in this issue, are given the results of his study of the dilution of lubricating oils in airplane and automobile engines. This, and the paper by Lieutenant Jackson, constitute two important reports on research and investigation as a result of war activities.

Henry Hess takes up the Question of Employment

Questions of labor and employment are receiving more attention among the industries than any other single problem. Remedies suggested for the present unrest are usually palliative, whereas Mr. Hess presents a constructive suggestion for a national program designed to get at the basis of the trouble and remedy the causes of unrest.

Society Activities and Public Affairs of Interest to the Engineer

The contents of this number of MECHANICAL ENGINEERING is an indication of the breadth and extent of the field now occupied by the engineer. There are twenty pages devoted to live news on these subjects relating to the activities of the A.S.M.E., important developments in other engineering societies, coöperative movements among engineers, Government and legislative matters, etc. Engineers' salaries are discussed and an account is given of developments toward a federation of engineering societies.

MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 42 March 1920 Number 3

The First Transcontinental Motor Convoy

An Account of the Successful Attempt Made by the War Department to Push Through a Large Train of Heavily Loaded Motor Trucks from Washington, D.C., to San Francisco, Together with Particulars of the Itinerary, Personnel, Operation and Maintenance Problems, and Conclusions Reached

By E. R. JACKSON,[1] WASHINGTON, D. C.

THE Transcontinental Motor Convoy which started from Camp Meigs, Washington, D. C., at 8 a. m. on July 7, 1919, and finished at San Francisco, Cal., on September 6, 1919, was the first attempt to push through a large train of heavily loaded trucks from one end of the country to the other. Back of it were placed the resources of the War Department, and some measure of its success was due to the friendly co-operation of the local bodies of the communities through which the Convoy passed.

Objects of the Trip

The four purposes of the trip were as follows:

1 The War Department's contribution to the Good Roads movement for the purpose of encouraging the construction of through-route and transcontinental highways as a military and economic asset.

2 The procurement of recruits for the enlisted personnel of the Motor Transport Corps, or any other branch of the U. S. Army, young men to be enlisted with the train as candidates for the mechanical training schools opened under the direction of the Motor Transport Corps.

3 An exhibition to the general public, either through actual contact or resulting channels of publicity of the development of the motor vehicle for military purposes, which is conceded to be one of the principal factors contributing to the winning of the World War.

4 An extensive study and observation of terrain and standard army motor vehicles by certain branches of the army, particularly the Field Artillery, the Coast Artillery, the Air Service, the Corps of Engineers, and the Ordnance Department.

The writer was acting as Ordnance Observer for the Chief of Ordnance, attached to the Transcontinental Motor Convoy, and accompanied this truck train the entire distance from Washington, D. C., to San Francisco.

The Convoy departed from Camp Meigs at 8:30 Monday morning, July 7, 1919, proceeding to the Ellipse in Potomac Park, opposite the south front of the White House, where the Zero Milestone was dedicated by the National Highways Association in the presence of the Secretary of War, the Chief of Staff, general officers of the Army, and several Senators and Congressmen. Following his acceptance of the Zero Milestone on behalf of the President of the United States, Secretary Baker formally directed the Convoy to proceed overland to San Francisco, Cal., via the Lincoln Highway.

Itinerary

Several days before it started the Convoy received from the Motor Transport Corps an itinerary giving scheduled control points, mileage and dates of arrival. Orders were given by the Secretary of War and Brig.-Gen. C. B. Drake of the Motor Transport Corps, to hold to the schedule as closely as possible, and it is noteworthy that the Convoy arrived at Lexington, Neb., almost exactly half-way across the continent, on August 1 on time, thanks to the good roads of Pennsylvania, Ohio, Indiana and Illinois and to the fact that the gumbo roads of Iowa were dry and hard, there having been no rain in that state for several weeks previous to the arrival of the Convoy.

From this point west and until the Convoy reached the palm-lined boulevards of California the roads grew steadily worse except in the vicinity of Salt Lake City, Utah, and it became increasingly difficult to get the heaviest trucks through the soft, muddy roads and over the bad grades. The greater part of the Convoy trucks could not have reached San Francisco without the assistance rendered by the Militor and the 5-ton artillery tractor, produced by the Ordnance Department.

FIG. 1 ROUTE OF THE FIRST TRANSCONTINENTAL MOTOR CONVOY—CAMP MEIGS, WASHINGTON, D.C., TO SAN FRANCISCO, CAL., JULY 7, TO SEPT. 6, 1919

[1] Former 1st Lieut., Ord. Dept., U. S. A. Ordnance Observer.

For presentation at the Spring Meeting, St. Louis, May 24 to 27, 1920, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. All papers are subject to revision.

PERSONNEL

The personnel of the Convoy consisted of Companies E and F of the 433d Motor Supply Train, comprised of 12 officers and 210 men; Service Park Unit No. 595, 1 officer and 38 men; Company E, 5th Engineers, 2 officers and 30 men; 1 Medical Detachment; 1 Field Artillery Detachment; and 17 commissioned officers detailed to duty as staff observers.

The majority of the enlisted men of the Motor Supply Train were raw recruits with little or no military training, many of whom had not driven a motor truck before. Considering this fact, the success of the Convoy is quite remarkable, as the roads encountered through the mountains of the West required driving skill of the highest order. The men were poorly equipped at the start, due to the fact that many of them joined at the very last minute.

FIG. 2 ARTILLERY TRACTOR USED TO PULL BIG TRUCKS OUT OF BAD SPOTS. REPAIRING A BROKEN TRACK LINK

FIG. 3 CLASS B TRUCKS, CHAINED TOGETHER, MAKING GRADE AFTER FIRST ONE HAD BEEN TOWED OVER TOP BY TRACTOR, EAST OF BIG SPRINGS, NEB., AUG. 6, 1919

The other units were better trained and better equipped. The Engineer Corps and the Medical Detachment were especially efficient organizations. Much credit should be given to the Engineers for the extremely valuable work which they did in repairing roads and bridges, without which the expedition must have failed. The Medical Detachment handled all matters of camp sanitation and precautionary measures in a most satisfactory manner and as a result practically the entire personnel enjoyed excellent health during the whole trip.

OPERATIONS

The Convoy was made up of 81 motor vehicles and trailers. The performance of the various types of motor equipment is one of the chief points of interest to the engineering fraternity, inasmuch as it affords a most excellent opportunity for making valuable comparisons as to the ability and reliability of the several makes of motor vehicles and trailers. Practically all of the equipment was new when the Convoy left Washington, the exceptions being the Militor (the standardized four-wheel-drive motor vehicle of the U. S. Army) and the 5-ton artillery tractor, both of which were designed and built by the Ordnance Department, so that in so far as the condition of the vehicles was concerned, all had an equal chance of successfully completing the long journey across the continent.

While the cargoes carried varied somewhat from day to day, it may be said that in general the trucks hauled capacity loads. The most uncertain factor in the operation of these motor vehicles, especially during the first few weeks of the trip, was the

FIG. 4 TRUCK STUCK IN MUD SO BADLY THAT A 1¾-IN. MANILA ROPE AROUND WINCH OF MILITOR BROKE

FIG. 5 MACK TRUCK BREAKING THROUGH SMALL WOODEN BRIDGE, 31 MILES WEST OF GREEN RIVER, WYO., AUG. 15, 1919

inexperience of the drivers, all of whom were new to convoy work. Even during the first half of the trip, where the roads were generally good, some drivers had considerable difficulty in keeping their trucks on the road. After the train officers had had ample opportunity to observe the comparative ability of the men for a few weeks, the best drivers were each assigned to one of the motor vehicles with an assistant driver and made fully responsible for the operation of their equipment. Immediately upon arrival at the control point for the night it was the duty of the driver to see that his truck was at once filled with gasoline, oil and water, cleaned, and any needed adjustments or repairs made. Three officers of the Motor Transport Corps inspected each vehicle every morning before the Convoy left camp, to see that

this work had been properly done. This resulted in a very marked lessening of mechanical troubles on the road and a much more efficient operation of the entire equipment. As the Convoy proceeded across the country the men gained experience with their trucks and confidence in themselves, so that by the time the mountains and deserts were reached most of them were equal to the difficult tasks encountered there, and when the train reached San Francisco many of the men were really competent drivers, and their development as such is deserving of favorable comment. It is a truly noteworthy achievement that there were no trucks lost on the very dangerous mountain grades of the Rockies and Sierras.

Excellent work was done by the two pilots, who left camp on motorcycles each morning about one-half hour in advance of the Convoy to see that the road was clear and to report any obstructions or deviations to the expeditionary commander. The simple road-marking system used by the pilots proved to be a great success. The markers consisted of salmon-colored paper isosceles right-angle triangles which were tacked on a conspicuous post or fence at each turn of the road or intersection. When the apex of the triangle pointed up it indicated that the route was straight ahead; apex pointing to the right indicated right turn; apex pointing left, left turn; and two triangles tacked up base to base, thus forming a square, indicated the location of the camp site. Without these markers considerable difficulty would have been experienced in following the route through cities, on detour, in the absence of official Lincoln Highway markers, or where those were interspersed with other highway markers.

Fig. 6 Noon-Stop at Highest Point on Lincoln Highway, 8020 Ft. Elevation, Between Laramie and Medicine Bow, Wyo., Aug. 11, 1919

Fig. 8 Convoy Passing Highest Point on Lincoln Highway at Ames Monument in Wyoming, 8020 Ft. Above Sea Level, Aug. 11, 1919

Fig. 7 Militor Pulling Class B Truck out of Ditch near Grand Island, Neb., by Using Winch

Fig. 9 Class B Truck so Firmly Stuck in Quicksand that even the Tractor Tread Spun

Maintenance

The maintenance and repair of the Convoy vehicles was the principal function of Service Park Unit No. 595, and the fact that only three trucks were retired from service en route bears tribute to the effectiveness with which they did their work. Included in this detachment were expert mechanics on motorcycles, motors, carburetors, magnetos, radiators, and tires, machinists, painters, welders, blacksmiths, and carpenters; each man a specialist in his own line of work. These men did very excellent work in general, frequently working all night in order to have some truck ready to run under its own power when the Convoy broke camp in the morning, and some very clever repairs were made with the facilities available. New connecting-rod bearings were fitted frequently, damaged cylinder blocks replaced, cracked crankcases repaired, new clutch assemblies installed, and even babbitt bearings poured on the roadside very satisfactorily.

The maintenance work was considerably hampered because of the necessity of carrying spare parts for so many different makes of trucks and the additional fact that the stock carried had not been intelligently selected. Large stocks of such parts as axles and drive shafts, among which there were no breakages, were carried, while no spares whatever were taken of many other parts, including radiators, on which there were frequent failures. In a few instances it was possible to replace a broken or worn part in one truck with a spare part for another make of truck, when careful calibration showed the dimensions to be practically the same. Another difficulty was due to the poor quality of the hand tools supplied, and better tools should be furnished the

mechanics, as well as such special tools as are necessary to make certain adjustments properly.

General Conclusions

In general, very few serious automotive troubles developed, but the experience gained on the trip and the information secured from an examination of each vehicle after arrival at San Francisco would seem to warrant the following statements:

Cooling Systems. The vertical tubular type of radiator, with bolted-on upper and lower tanks, is the most satisfactory on military vehicles, because of the facility with which it may be cleaned and repaired. The addition of a temperature regulator in the water line, which would restrict the flow of water until the motor had warmed up and such as is now standard equipment on many commercial trucks, would be most desirable. Such a device would be simpler and less expensive to install than radiator shutters, less liable to damage, and is automatic in its operation.

An endless flat fan belt, of leather or rubberized fabric, is most desirable for military motor vehicles, and an effort should be made to standardize the width and length of these belts. An extra endless belt should be carried in each vehicle at all times. The "V" fan belts are not desirable, but if used, some form of a dust pan should be placed in front of the lower fan-belt pulley to protect the "V" belt.

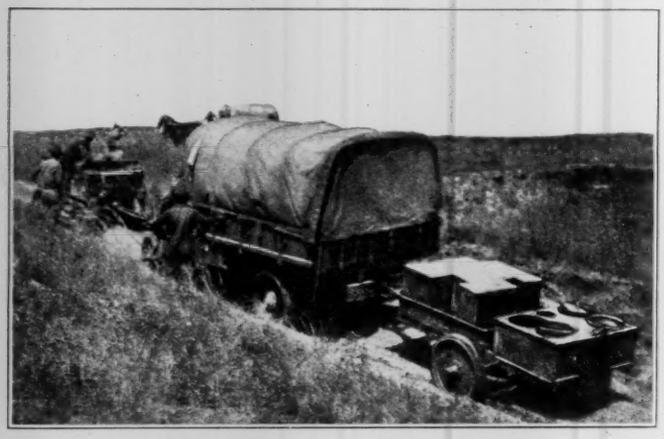

Fig. 10 Class B Truck, Towing Two-Wheel Liberty Kitchen Trailer, Stuck on Sandy Grade, and Towed over by Tractor

Motors. Because of the high percentage of failures experienced with certain valve-tappet rollers and guides and the valve springs, prompt attention should be paid to the development of a more durable valve-lifter assembly, which will be interchangeable with that now in use. It is suggested that steel be used in the construction of the guide instead of cast iron, as at present, and that the valve springs be heat-treated more carefully.

The governors of all trucks in the Convoy were rendered useless during the first few days of the trip, resulting later in many burned-out connecting-rod bearings, due to speeding the vehicles. Some means should be provided to protect the governors against tampering on the part of drivers and mechanics.

A simplified carburetor would be advantageous on cars having sensitive automatic throttle and auxiliary air valve, as these are not thoroughly understood by the average mechanic.

Only the very best grades of oil should be used in motors, and a simple and positive means of determining the oil level should be provided on every truck.

A study should be made of the conditions which are responsible for the blowing out of cylinder-head gaskets in the motor of the Standardized Class B trucks, and such changes made as may be necessary to eliminate this trouble.

The mufflers on some of the trucks were found to clog up easily and this matter should be given careful attention.

Ignition and Electrical Systems. The Bosch magneto used on the Standardized Class B truck should be corrected to have a greater air gap between the pencil and the distributor block.

The present acetylene headlights used on all trucks are entirely inadequate, and the carbide generators are unsatisfactory and poorly constructed. It is believed that an efficient system of electrical lighting should be adopted for all military trucks. Such a system was developed for the Ordnance Department during the war by Mr. R. M. Newbold and found satisfactory.

The use of mechanical or electrical self-starters on military vehicles is undesirable, as they merely add complications to the operation and maintenance of the trucks.

All service cars should be equipped with four electric spotlights for night repair work.

Fuel Systems. Except for a few broken gasoline lines the fuel systems now in use are generally satisfactory, although larger drain cocks in all gasoline tanks would be desirable.

Transmission Systems. A driving worm of 24 pitch instead of $33\frac{1}{3}$ pitch is recommended for all Class B trucks. Of the three Class B tankers, the one with the $33\frac{1}{3}$-pitch worm was the one which was most frequently stalled.

It is recommended that steps be taken to have all future military motorcycles equipped with a complete protective guard around the drive-chain system. Some steps should also be taken to provide for a unit power plant, eliminating the short drive chain. In future development steps should be taken to eliminate the chain drive entirely and to substitute shaft drive. There are no insurmountable difficulties to the inclusion of this type of drive in a motorcycle, but it cannot, however, be applied when the V-type two-cylinder motorcycle motor is used.

Fig. 11 Ordnance-Built Tractor Pulling Heavy Trucks out of Mud near Gothenburg, Neb., Aug. 3, 1919

Chain-driven trucks cannot be operated satisfactorily where soft, sandy or muddy roads are encountered. They are essentially good-roads trucks.

As an automotive principle the four-wheel drive was surely vindicated by the Militor and the F. W. D. trucks. It is believed that the Militor is the most powerful wheeled motor vehicle constructed up to the present time.

Vehicle Controls. The steering gears gave very little trouble, but better lubricating facilities are desirable to secure the ease of steering which is so necessary on a motor truck, especially when operating on heavy roads, as some types are very hard to operate on rough roads.

On one class of trucks the brake rods are placed too close to the springs and there is frequently wear between these parts.

Front Axles. There were no front-axle troubles due to any inherent mechanical faults.

Rear Axles. No serious rear-axle trouble developed on the road other than stripping some teeth out of two ring gears in one make of car. All worm gears operated without any signs of overheating under the heaviest pulls. Increased ground clearance under most rear axles would be very desirable.

Wheels and Tires. All trucks for military use should have cast-steel wheels; and passenger automobiles for the army, wheels of the pressed-steel disk type.

Solid tires for trucks should be of the Giant type instead of the Dual type, as the Giant type gives better traction and apparently stands wear better than the Dual type. This was especially noticeable in the deserts, where a ridge of sand was pressed in between the two halves of the Dual tires, virtually eliminating the ground pressure of the tread, and thus reducing the tractive effort. Furthermore, the manufacturers have practically ceased production of Dual tires and are centering all their energies upon the construction of Giant tires.

Chasses. The frames of all vehicles completed the journey with no apparent damage. All frames were in alignment and only one case of deflection was observed. Rear bumpers should be placed on all trucks, and a stronger bumper, possibly with steel facing, should be used on military vehicles. Many towing hooks straightened under pull, and a much stronger hook should be developed.

Bodies. In two makes of 1½-ton trucks the body sills had to be cut out for wheel clearance and attention should be paid to this matter.

Tankers are overloaded and the center of gravity is too high. Slush was responsible for one overturning. Bumper should be in rear of faucets to protect them.

Equipment. Horns loosened up from vibration, and should be more securely attached to the body.

Tool boxes should be of heavier construction in order to withstand the very hard usage to which they are subjected in the field.

RESULTS

It is the opinion of the Ordnance Observer that the First Transcontinental Motor Convoy, as the pioneer undertaking of its kind, was a successful operation, and that the experience gained during this trip will prove invaluable, not only to the Army, but to all users of motor trucks in general.

All along the route great interest in the Good Roads Movement was aroused by the passage of the Convoy, and it was reported that several states had voted favorably on large issues of road bonds. However, the officers of the Convoy were thoroughly convinced that all transcontinental highways should be constructed and maintained by the Federal Government, because the sparsely settled states of vast area in the Rocky Mountain region are absolutely unable to finance their own section of such a project. The Townsend Bill, now before Congress, provides for just such an undertaking under a Federal Highway Commission, and it is earnestly hoped that this measure may be favorably acted upon at an early date, in order that the nation may be ready for the commercial "Ship by Truck" movement.

FIG. 12 DISTANT VIEW OF CONVOY GOING OVER THE GREAT SALT LAKE DESERT, AUG. 22, 1919

FIG. 13 CLASS B TANKER RUNS OFF ROAD ON OLD RAILROAD GRADE AND TURNS OVER 270 DEG. NEAR RAWKINS, WYO.

Whenever a train is started out for other than experimental purposes the trucks should be of the same type and tonnage, thereby eliminating the number of spare parts necessary to be carried.

For the mobile army light trucks not to exceed 2-ton capacity should be the practice. The heavier trucks should be used in the rear areas only.

With reference to shop trucks, no fixed tops should be used. The general scheme of using bows and paulins should be followed, because the fixed top is unnecessary, as it adds to the weight of the truck and often is an encumbrance in the passage of low bridges and low-hanging branches.

The equipment on the machine-shop trucks should be rearranged to provide greater accessibility, placing the motor-generator set where the lathe now is, across the forward end of the body, and locating the lathe transversely at the rear of the body. A double bench could then be placed across the body at the center, with the drill press on one end and the grinder on the other, and four vises of various sizes and types could be attached as convenient.

Some provision should be made on all trucks to permit both sides of the hood to be folded up and securely retained in that position. This would enable two men to work on opposite sides of the motor at the same time, and would make it possible to increase the circulation of air around the motor in very warm weather. A more sturdy form of hood clip should be developed.

The rope cleats and stake pockets all worked loose and a better means of fastening them should be used.

Floor boards are too weak and should be made of heavier gage stock. Laminated floor boards did not prove to be satisfactory.

Although the number of enlistments actually secured by the recruiting officer was not large, great interest in the various activities of the Army was stimulated throughout the regions covered by the Convoy, and reports from recruiting stations indicate that several hundred recruits were obtained as a direct result of the Convoy.

The interest of the general public in the Convoy was evidenced by a whole-hearted hospitality which never failed from beginning to end of the trip, and which was quite as spontaneous in the small towns as in the larger cities. Everybody was glad to see the trucks and the men, who were showered with every variety of refreshments all along the route. In the larger towns and cities luncheons and dinners were served, entertainments and dances given, and the clubs and many homes opened to the entire personnel. Great credit should be given to the Red Cross Canteen Service, the War Camp Community Service, the Knights of Columbus, the Y. M. C. A., the Chambers of Commerce, the Commercial Clubs, the Elks, and many similar organizations, who served the Convoy with distinction all the way "from Coast to Coast."

In the operation and maintenance of a motor-truck train many valuable lessons were learned, which warrant the following recommendations:

That extended use of triangular signs, bearing the designations of the unit using them, as road markers is invaluable.

That there should always be a very careful inspection of all

vehicles for the proper amount of gasoline, oil, and water before departure on any run, no matter how short.

That a light touring car or light delivery car replace the present motorcycle with side car, which cannot negotiate soft, sandy or muddy roads successfully, and is a single-purpose vehicle.

That Class B trucks are too heavy for use in the field, except in the rear areas, on good roads and over strong bridges.

That only trucks of the four-wheel-drive type be used with artillery because of the ease with which they negotiate any sort of rough terrain, sand or mud, in any kind of weather.

That two Class A trucks be used instead of one Class B truck wherever there are unimproved roads or doubtful bridges.

That every Service Park Unit and Repair Base should have a Militor with winch for wrecking.

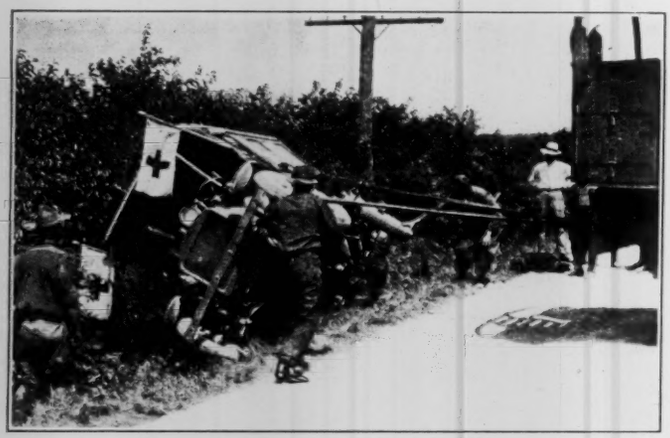

FIG. 14 CLASS B SPARE-PARTS TRUCK RIGHTING OVERTURNED G.M.C. AMBULANCE NO. 39309 EAST OF CHICAGO HEIGHTS, ILL., JULY 19, 1919

That the Militor should have a longer and stronger sprag, of the artillery type, similar to the spade of a gun-carriage trail; or perhaps two such sprags, one on each rear corner of the frame; that the cable reel should be placed on a squared shaft to facilitate rewinding and should be located ahead of the winch and guide sheaves which should have universal support.

That spare-parts trucks should have a stock-record card system, and that the arrangement for packing the parts be improved so that such articles as bearings may be protected with individual boxes or cartons.

That every effort be made to coöperate with carburetor manufacturers toward the production of a carburetor of the jet type suitable for use on motorcycles.

DAILY LOG OF THE TRIP

A log was maintained in which the incidents occurring were written day by day. It makes interesting reading and gives a clear idea of the difficulties which the train had to overcome. A few of the incidents recorded may be of particular interest; for instance, those inserted in this abridged report.

As stated, the train departed from Camp Meigs, Washington, D. C., at 8:30 a. m., July 7, 1919.

Already on July 9 some of the trucks were held back by broken accelerator springs and sticky exhaust valves losing compression. Ignition troubles of various nature developed and various types of trucks also developed considerable magneto trouble.

Considering the personnel was untrained, the driving could be called excellent.

On July 12 on one truck the main-drive shaft had been twisted off in the transmission bearing by an inexperienced driver throwing in the reverse gear and dropping in clutch while the motor was turning over at high speed on down grade. The driver did it to use the motor as a brake.

On July 17, departed Delphos at 6:30 a.m. Difficulty was experienced in starting several motors on account of low-gravity gasoline.

To give an idea of the main troubles encountered under the strenuous conditions of the run the log on July 23 is reproduced in its entirety.

Departed Clinton, 6:30 a. m. White Staff Observation Car No. 111,506 delayed in starting on account of oil-pump plunger sticking. Class B No. 414795 stalled with oil-soaked magneto 6 mi. out. Class B spare parts truck No. 414668 taken in tow by Militor on account leaking cylinder-head gasket—would not pull on hills. This truck gave some trouble yesterday, but was not repaired in Clinton. Porcelain of one AC spark plug was broken. 3 mi. west of Lowden, Class B No. 80215 stopped to clean out gasoline line. Fender fell off 2-wheel kitchen. Starting crankpin breaks on one class B and another has trouble with back-firing in carburetor. Trailmobile kitchen breaks right rear spring through all leaves in center. Class B machine shop

FIG. 15 MILITOR WINCH PULLS SO HARD ON CLASS B TRUCK, STUCK IN SAND, THAT IT RAISES ITS OWN REAR WHEELS OFF THE GROUND AND STANDS ON THE SPRAG. TEN MILES WEST OF NORTH PLATTE, NEB., AUG. 5, 1919

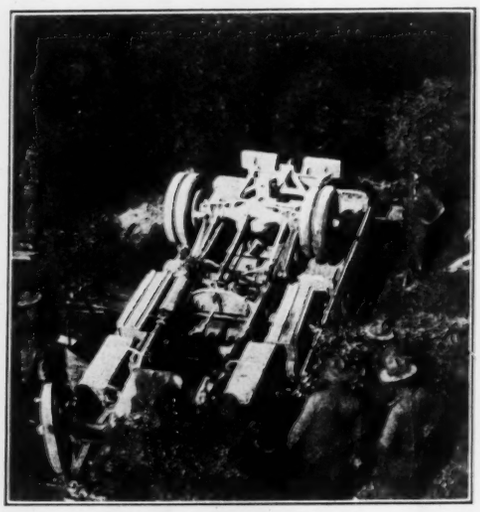

FIG. 16 VIEW OF RIKER TRUCK BELONGING TO COMPANY E, 5TH ENGINEERS, TURNED OVER IN DITCH NEAR FULTON, ILL., JULY 22, 1919

truck No. 414,319 went through small culvert bridge and had to be jacked up and pulled out by Militor. Convoy escorted into Cedar Rapids by Lt. Gov. Moore, Mayor Rall, etc. Dinner served to entire command by Chamber of Commerce and Rotary Club. Made 87 miles in 10½ hr. Fair and warm. Good hard dirt roads. Arrived Cedar Rapids, Iowa, 5 p.m.

(*Continued on page 205*)

Turbo-Compressor Calculations

By ALLEN H. BLAISDELL, PITTSBURGH, PA.[1]

After pointing out the features which differentiate the turbo-compressor from the multi-stage centrifugal pump, the author takes up the study of the pressure and volume changes occurring while a fluid is passing through one stage of the former and states the fundamental energy equations involved. He then discusses the number of stages to be used in a given case and follows this with an explanation of the method of laying out a compression diagram and of subdividing it according to the number of stages to be provided for.

The function of the impeller is next discussed and in this connection expressions are derived for the actual and effective impeller radii and the axial depth of channel of any radius. Blades and blade angles are also considered and a graphical method is described for calculating the theoretical head to be developed by an impeller.

The paper concludes with a brief study of the working of free-vortex and guide-vane diffusers, and of matters to be taken into account in designing in order to obtain a turbo-compressor of the highest possible overall efficiency.

IT is well known that the turbo-compressor is quite similar in its nature to the multi-stage centrifugal pump. Whatever differences exist between the two types of machines is due to the fact that one handles a gaseous medium while the other handles a practically incompressible fluid, water. Both are high-speed machines.

The impellers of multi-stage centrifugal pumps are of the same size throughout, but those of turbo-compressors should be theoretically of continually diminishing dimensions because of the decrease in volume of the fluid as it is compressed from stage to stage. Actually the impellers are divided into two or more groups and each group calculated for its own average conditions. Since the capacities of these machines rarely exceed 50,000 cu. ft. per min., and in general range from 7000 to 10,000, the single-flow type of impeller is used in most turbo-compressors.

The only other important feature which differentiates the turbo-compressor from the centrifugal pump is the arrangement made for cooling the fluid as it passes through the compressor. In the reciprocating compressor practically all cooling is accomplished by means of intercoolers located between the different stages, the water jackets of the cylinders having but slight effect on the temperature rise of the fluid which is being compressed in the cylinders. In turbo-compressors the cooling is accomplished in two ways (*a*) by means of cooling coils between each stage, and (*b*) by means of carefully designed water jackets. The water-jacket method is much more effective in the case of the turbo-compressor than in that of the reciprocating machine because the fluid being compressed has a more intimate contact with the cooling surfaces.

The discussion will be divided into three main divisions:

A Thermodynamic Considerations
- *a* Study of the nature of the compression
- *b* Fundamental energy equations
- *c* Layout of compression diagram

B Pneumatic Considerations
- *a* Theory of fluid flow
- *b* Essentials of impeller design
- *c* Essentials of diffuser design

C Power Consumption and Efficiency.

(*A*) THERMODYNAMIC CONSIDERATIONS

Nature of the Compression

Fig. 1 shows in section a portion of two stages of a multi-stage centrifugal or turbo-compressor. The fluid being compressed enters the impeller at *a* with a definite pressure, velocity and temperature. The impeller, rotating with a high speed, discharges the fluid with an increased pressure, temperature and velocity. Leaving the impeller the fluid enters the diffuser, where its velocity is greatly reduced and its pressure increased. The temperature will also be reduced somewhat, due to the cooling water which passes through the diffuser vanes. At *d* the fluid leaves the diffuser and passes down between guide vanes, during which interval it is in contact with water-cooled surfaces *f*, and suffers a still further reduction of temperature and volume. At *c* the fluid enters the succeeding impeller, where it goes through a similar cycle.

The change of state of the fluid being compressed will follow the law $pv^n = \text{constant}$. The value of the exponent n is governed by the kind of fluid being compressed, the moisture condition of the fluid and by the surrounding thermal conditions. When the fluid being compressed neither receives heat from, nor gives up heat to, surrounding bodies the compression is called adiabatic, and under these conditions $n = 1.41$ for air. When

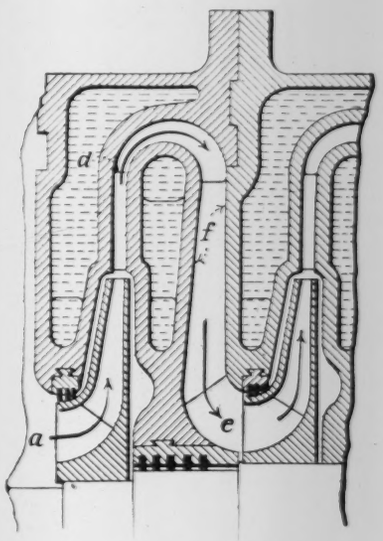

FIG. 1 SECTION OF PORTION OF TWO STAGES OF A MULTI-STAGE CENTRIFUGAL OR TURBO-COMPRESSOR

the nature of the compression is such that the temperature remains constant, then the compression is said to be isothermal and $n = 1$ for all gases.

It is very difficult to say exactly what pressure and volume changes occur while a fluid is passing through one stage of a turbo-compressor. The energy transfer to the fluid occurs in the impeller, which changes the angular momentum of each fluid particle, work being done upon the fluid as a whole. As a result of this energy transfer the fluid on exit from the impeller possesses an increased pressure and velocity. But this pressure is not the total pressure developed in the stage, and herein the action in a turbo-compressor differs somewhat from the reciprocating class of machines. In the reciprocating compressor work is done by the piston upon the fluid enclosed in the compressor cylinder, first compressing the gas to the discharge pressure and then ejecting the fluid from the cylinder. In the case of the turbo-machine the impeller does work upon the fluid which results in an increase not only of pressure but also of velocity, and if the amount of work is the same in both instances it is quite evident that the pressure rise in the impeller will not be so great as in the case of the reciprocating compressor, since a portion of the

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energy imparted to the fluid has the kinetic form. Consequently, in order to secure as large a pressure rise as possible, use is made of a diffuser wherein no further work is done on the fluid, but a portion of its velocity head is changed over into pressure head.

It is possible to study the pressure and volume changes in the impeller of a turbo-compressor by means of a pv-diagram just as in the case of the reciprocating machines. Thus, in Fig. 2, $ABCD$ may be considered as representing what occurs in an impeller. The line BC will be the actual compression curve and must be located outside of the adiabatic BF. This is quite easy to understand, since there is likely to be but very little heat transfer through the walls of the impeller to or from the fluid because of the short interval of time which elapses while the fluid is passing through the impeller. Because of friction, impact, eddying and turbulent flow, extra work is done and this results in a compression which follows the polytropic curve BC rather than the adiabatic BF. This means that the value of the exponent n in

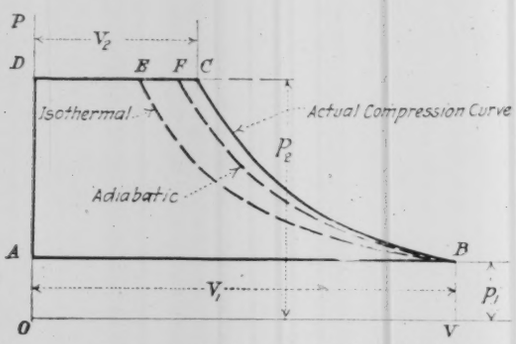

FIG. 2 DIAGRAM SHOWING PRESSURE AND VOLUME CHANGES IN THE IMPELLER OF A SINGLE-STAGE TURBO-COMPRESSOR

pv^n = constant will be greater than 1.41. The temperature rise of the fluid must consequently be in excess of that due to adiabatic compression alone, and hence it is very essential that every effort be made to cool the fluid after it leaves the impeller, since by so doing the temperature and volume will be reduced before entrance into the succeeding stage and consequently the compression work of that stage will also be diminished.

Of the total energy imparted to the fluid in the impeller only a portion is in the form of pressure, the remainder being used up in increasing the velocity. Such being the case the expression for total work must contain a term to include the increase of kinetic energy as well as a term to cover the work of compression.

NUMBER OF STAGES

The number of stages to be used depends upon the total pressure to be developed by the machine and the speed of the prime mover. Since the fluid being compressed is a gas and the terminal pressure for a single stage is proportional to the density of the gas, it is evident that a large number of stages will be required if very high delivery pressures are desired.

In selecting the proper number of stages a compromise has to be made between a few stages with large-diameter impellers and a large number with impellers of small diameter. If large impellers are used the frictional losses due to the fluid drag of the fluid on the impeller will be excessive, reducing the overall efficiency of the compressor. On the other hand, if small impellers are used the pressure rise per stage will not be so large and this means an increase in the number of stages, with a consequent increase in the cost of production, but the efficiency will be better than that of the first machine. In addition to reduced frictional losses there will also be a decrease in the compression work, and this factor helps to raise the efficiency above that of the machine with a small number of stages.

For equal amounts of compression work per stage the pressure developed will not be equal but will increase from stage to stage. If the stages are divided into two or more sets, all impellers of a single group having the same diameter, then the same fact applies, but in this case the pressure rise will be the average for the group.

LAYOUT OF COMPRESSION DIAGRAM FOR TURBO-COMPRESSOR

For illustrative purposes only, let us suppose that the diagram of Fig. 3 is that of a four-stage compressor. It is desired to study the peculiarities of the diagram and develop a graphical method of constructing such a diagram. The method to be explained was originated by M. de Stein.

The total energy transfer from all the impellers to the fluid passing through them is represented in the diagram by area $ABCDEFGHIK$. In other words, area $ABCD$ is an equivalent pv-diagram for the first stage and represents not only the work of compression in the impeller but also the increase of kinetic energy. In the same way does $D'DEF'$ represent the energy transfer for the second stage. In other words, if p_1 is the inlet pressure to the first stage, then p_2 is the delivery pressure from the diffuser, and not the impeller. Consequently, the total pressure rise for the stage (impeller and diffuser) is $p_2 - p_1$. Such being the case, p_5 will be the delivery pressure of the machine if the kinetic energy in the fluid when discharged is neglected. The pressures p_2, p_3 and p_4 may be considered as the static pressures which exist between the diffuser of one stage and the entrance to the impeller of the following stage.

Good design necessitates that the areas $ABCD'$, $DEF'D'$, etc., shall be equal or that the energy delivered to the fluid shall be the same for each stage. The lines BC, DE, FG are laid out as adiabatics. If the cooling is effective they will all lie in closer proximity to the isothermal BM than the adiabatic BN. When there are a large number of stages, say eight or ten, it is allowable to assume the curve BJ (passing through points D, F, H) as representing the equivalent compression curve.

To lay out the pv-diagram $ABJK$ for the machine requires that we shall know the initial pressure p_1, the initial volume v_1, in cu. ft. per lb., the delivery pressure p_5 and the value of n in pv^n = constant in order that the curve BJ can be drawn.

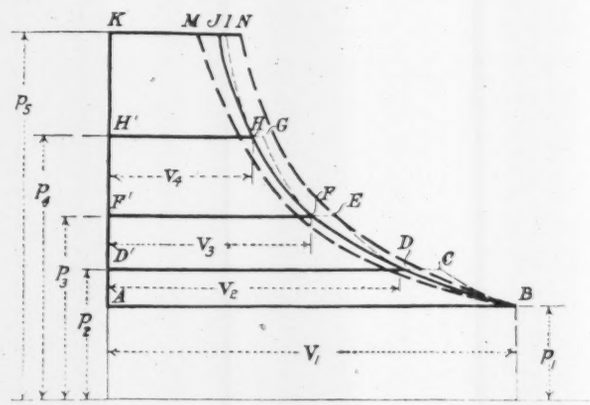

FIG. 3 COMPRESSION DIAGRAM FOR A FOUR-STAGE COMPRESSOR

Having laid out the isothermal and adiabatic curves it is now necessary to lay out the compression curve for the machine. In order to do this it is practically necessary to assume the position of point J of the compression curve such that

$$v_J \eta_a (v_M - v_N) + v_N \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where η_a = adiabatic efficiency and v = volume in cu. ft. per lb.

When the compression is adiabatic, if the final temperature is T_N deg. abs., the adiabatic efficiency, or ratio between the theoretical internal work and the work actually furnished for the compression, can be expressed by

$$\eta_a = \frac{T_N - T_1}{T_J - T_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

where

T_J = final temperature in deg. abs. with adiabatic compression
T_N = final temperature in deg. abs. with actual compression
T_1 = initial temperature in deg. abs.

If frictional resistances are considered, then the value of τ_{ia} as calculated from [2] will be increased about 3 per cent.

(B) PNEUMATIC CONSIDERATIONS

DIVISION OF THE PRESSURE-VOLUME DIAGRAM

On completion of the actual compression diagram $ABJK$ (Fig. 5) it is next necessary to divide its area into the same number of parts as there will be stages or groups of stages in the compressor. In this instance it is four.

The total energy head developed by a single impeller or group of impellers can be stated in the form

$$H = \frac{p}{\delta_m} = K\frac{u^2}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

where

$K = \tau_{ip} \times \theta$

and

δ_m = mean density for a single stage, or group of stages
u = peripheral velocity of the impeller (or impellers) in ft. per sec.

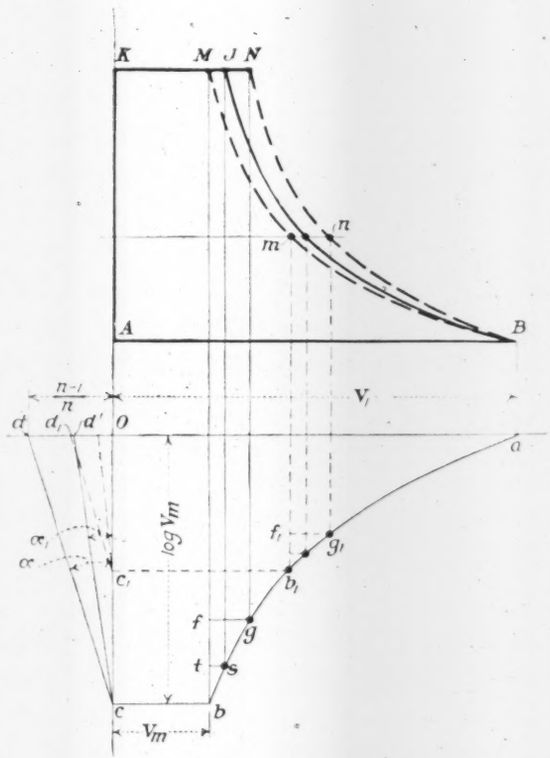

FIG. 4 METHOD OF LAYING OUT COMPRESSION DIAGRAM FOR TURBO-COMPRESSOR

τ_{ip} = pneumatic efficiency for a single stage, or group of stages
θ = form factor determined by the blade shape, angles, etc.
p = pressure rise for a single stage, or group of stages.

It is evident from Equation [3] that the compression diagram must be so divided into areas that the law pv = constant shall hold true; that is, all the areas into which the pv-diagram is divided must be equal.

The following graphical method can be used with great facility in carrying out this subdivision, particularly when there are a good many stages to be considered.

Let $ABJK$ (Fig. 5) represent the compression diagram for the compressor. We will assume, as before, that the machine has four stages only and proceed to divide this diagram into parts such that the areas will all be equal.

Divide the distance KA into any convenient number of equal lengths, say, six, marked by the figures 1, 2, 3, etc. Through these points draw horizontal lines 1-1, 2-2, 3-3, etc., cutting the diagram up into six trapezoidal areas which can be quite easily converted into equivalent rectangles as indicated in Fig. 6.

The areas of these rectangles are to each other as their bases. Reduce these bases by one-half, say, and add to each one of these the sum of the reduced lengths of the preceding ones. Through the ends of the lines thus drawn pass a smooth curve, $Aabcde C$. The length of any horizontal such as KC represents to scale the area between it and the lines JB, BA, and AK. In other words, because of the construction the length KC represents the area of the compression diagram. Such being the case, if we divide KC into the same number of equal parts as there will be stages, or groups of stages (in this instance, four) and through the division points H, F, D, drop verticals intersecting the curve AC at I, G, and E, respectively, then horizontals through I, G, and E will

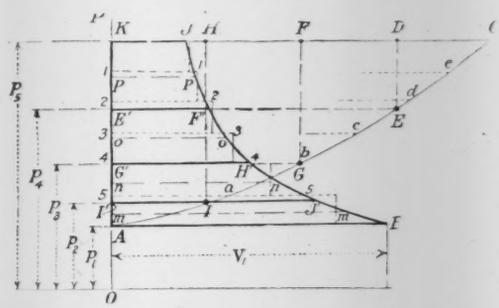

FIG. 5 PRESSURE-VOLUME DIAGRAM FOR COMPRESSOR

divide the compression diagram into four sections whose areas will be equal. The lengths AI', IG', $G'E'$, etc., will represent the total pressure head to be developed by each stage, or group of stages.

If the line AB represents the total volume of fluid taken into the compressor, then mm, nn, oo, pp, etc., will represent, to the same scale, the average volume for the various stages, or groups of stages. On the other hand, if AB represents the specific volume of the fluid drawn into the first stage, then mm, nn, oo, pp, etc., will represent to the same scale the average specific volumes of the different stages.

If Vm_1, Vm_2, Vm_3, etc., are the mean specific volumes just defined, Vm_1, being the mean specific volume for the first stage, then the mean densities are

$$\delta_1 = \frac{1}{Vm_1}; \qquad \delta_2 = \frac{1}{Vm_2}; \qquad \delta_3 = \frac{1}{Vm_3}; \text{ etc.} \ldots\ldots [4]$$

It has already been stated that the pressures developed per stage are proportional to the fluid densities. Hence the ratio of the total pressure developed in one stage to that of the following or preceding stage must be the same as the ratio of the mean densities. If p_2, p_3, p_4, etc., are the discharge pressures per stage, we have

$$\frac{p_2}{p_1} = \frac{\delta_2}{\delta_1}; \qquad \frac{p_3}{p_2} = \frac{\delta_3}{\delta_2}; \qquad \frac{p_4}{p_3} = \frac{\delta_4}{\delta_3}; \text{ etc.} \ldots\ldots [5]$$

where p_1 and δ_1 are the pressure and density of the fluid on entrance into the first stage.

If a group of stages is made up of n impellers and p is the total pressure increase for the group, we can assume the average increase per impeller and diffuser (or stage) as given by

$$\Delta p = \frac{p}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

In reality the pressure increases will not be the same, as we already know, but the resulting error has no effect on the accuracy of the calculations as a whole. By using Equation [6] we virtually assume that the fluid is incompressible for a group of

stages, or that the mean density of one stage is the same as those of the remaining stages of the group.

IMPELLERS AND DIFFUSERS

In the design of impellers and diffusers for turbo-compressors we are forced to depend on the theory of centrifugal pumps, which at its best is far from being satisfactory or complete for centrifugal pumps even, and of course is far less so when applied to turbo-compressor calculations. However, by making certain assumptions it is possible to utilize the theory with quite satisfactory results.

In order to simplify the analysis of fluid flow it is necessary to make the following assumptions:

a That the fluid has stream-line motion, i.e., the fluid particles move in non-intersecting curves

b That the fluid will, since it is elastic, completely fill the channel of flow

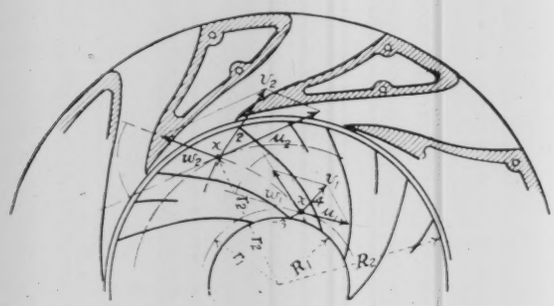

FIG. 6 GUIDE-BLADE CONSTRUCTION, SHOWING EFFECTIVE IMPELLER RADII

c That the motion of the fluid is steady, i.e., each fluid particle has the same mean velocity as every other particle which is moving along with it through any section and the static pressure is the same at all points of a section which is at right angles to the fluid flow.

d That the fluid is non-compressible.

THE IMPELLER

The function of the impeller is to impart a certain amount of energy to the fluid passing through it, with a maximum of efficiency. That is, friction, fluid impact, and turbulence should be reduced to a minimum.

On the assumption that the speed of rotation and the rate of fluid flow are known, there will be derived expressions for the actual and effective impeller radii, and the axial depth of the impeller channel at any radius. In addition to these there will also be given a brief discussion on blades and blade angles, together with the explanation of a graphical method for calculating the theoretical head to be developed by an impeller.

If we assume the impeller discharge to be zero, then from an equation given in the complete paper we obtain

$$W = \frac{144\, p_1 v_1}{\eta_i} \cdot \frac{n}{n-1}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right] \ldots\ldots\ldots [7]$$

where η_i = impeller efficiency, being practically identical with $\eta_1 R$, but applying to the conditions of zero discharge only. This expression actually represents the work of compression performed in the impeller against the contripetal forces of the fluid particles. Since these forces vary from a minimum at the impeller entrance to a maximum at the discharge, the work done in forcing one pound of fluid from entrance to exit is equal to the average value of the centripetal force multiplied by the radial distance through which the pound of fluid is to move (with a negligible velocity). Such being the case, we have

$$F \times (R_2 - R_1) = W \ldots\ldots\ldots\ldots [8]$$

where

F = centripetal force $= \dfrac{N^2}{5908}(R_2 + R_1)$

R_2, R_1 = actual outer and inner radii of the impeller in feet

N = r.p.m. of impeller

W = work of compressing 1 lb. of fluid in the impeller in ft-lb.

Substituting in [8] the value for W given by [7] we finally get, if $R_1 = aR_2$ and $\eta_i = 0.75$,

$$R_2 = \frac{1095}{N}\sqrt{\frac{p_1 v_1}{(1-a^2)}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right]} \ldots\ldots\ldots [9]$$

The value for R_2 given by [9] must be checked from the strength standpoint in order to fortify against the possible occurrence of dangerous stresses in the impeller at excessive speeds of rotation. In fixing upon final definite values for R_2 and R_1 care must be taken to see that the inlet area of the propeller is not too restricted, thus choking the fluid flow and causing an unnecessary loss of head at the impeller entrance.

The effective impeller radii r_2, r_1 (Fig. 6) are those at which the velocities w_2, u_2, v_2, w_1, u_1, v_1 are calculated and are not the same as the actual radii R_2, R_1. If an impeller is designed with velocity diagrams based on the radii R_2, R_1, it will be found that the impeller will not develop the desired head without an increase in the rated speed. It should be noted that if the impeller blades are radial at exit then the actual and effective radii (outer) will coincide. The determination of r_2 and r_1 is mostly a matter of judgment and will be taken up later on in the paper.

IMPELLER BLADES

Just what shape of blade should be used is largely dependent upon the type of characteristic desired. In Fig. 7, *a* and *b*, are shown typical constant-speed characteristics AB and AC. They represent in a general way how the pressure varies with the discharge from a single stage, curve AB referring to curved-back

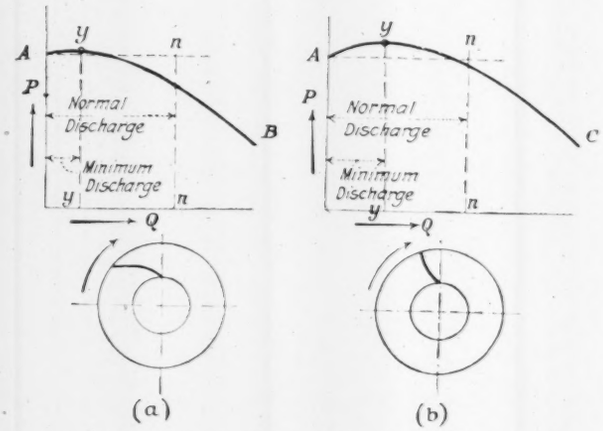

FIG. 7 TYPICAL CONSTANT-SPEED CHARACTERISTICS SHOWING HOW PRESSURE VARIES WITH THE DISCHARGE FROM A SINGLE STAGE

blades and AC to radial blades. Both curves are supposed to show the combined effect of the impeller and diffuser. If the diffuser has been properly designed to suit the impeller and the casing, the characteristics AB and AC will clearly indicate the effect of the blade shape on the nature of the pressure characteristic. It will be noticed that the slope of AB tends to grow steeper from the very first and the fact that it does rise at all is due to the effect of the diffuser. This so-called "drooping characteristic" is always typical when backward-curved blades are used. In the case of the radial blade the characteristic AC has a decided rise from point A and only starts downward some distance beyond A. Lines yy, in both figures, represent in a general way the relative locations of the maximum possible discharge pressure and the corresponding magnitude of the discharge. With leaning-back blades the minimum possible discharge (accompanying the maximum possible pressure) from the com-

pressor is about 30 per cent of the normal. With radial blades the minimum discharge ranges between 40 and 60 per cent of the normal, the normal discharge being indicated by lines mn for both cases. The location of this lower discharge limit is of much importance, for if the volume is reduced any further, "surging" or "pumping" ensues, with consequent severe oscillations of the machine.

The radial type of blade is used to a large extent in turbo-blowers where the discharge pressure seldom exceeds 46 lb. per sq. in. gage. By using radial blades it is possible to use larger impeller diameters for a given speed of rotation. This means fewer stages with impellers of a simple but very strong construction.

The claim is sometimes made that the curving back of the blades at the outlet secures only a very small increase in the mechanical efficiency, but that this is accompanied with a relatively greater loss of manometric efficiency. This fact may be of importance in the case of fans and blowers, but it does not apply with equal emphasis in the case of turbo-compressors where the absolute velocity of discharge from the impeller is kept down to as small a value as possible by use of leaning-back blades in the impellers. Under any circumstances it is very difficult to convert much more than 50 per cent of the kinetic energy of the fluid, when discharged from the impeller, into pressure. When diffusers are used as a means of carrying out the conversion it is quite necessary that the absolute discharge velocity from the impeller shall be a minimum, otherwise there will be large pressure-head loss because of impact, eddying, etc., as will be more fully explained later on in the discussion.

If radial vanes are used, however, it is essential that they should be curved at the inlet to suit the relative velocity of the fluid to the vane at that point. Some manufacturers divide the blade into two parts, making the larger external portion straight and radial, a form that can be easily machined, and attaching to this a curved part at the inlet, which being small can be readily machined.

The total fluid head against which the impeller must work can be expressed in the following three ways:

$$H = \frac{v_2^2 - v_1^2}{2g} + \frac{144}{\gamma_m}(p_2 - p_1) + J(i_2 - i_1) \quad [10]$$

$$H = \frac{v_2^2 - v_1^2}{2g} + \frac{u_2^2 - u_1^2}{2g} - \frac{w_2^2 - w_1^2}{2g} + J(i_2 - i_1) \quad [11]$$

$$H = \frac{u_2(u_2 - v_2\cos\alpha_2)}{g} + \frac{u_1(u_1 - v_1\cos\alpha_1)}{g} + J(i_2 - i_1) \quad [12]$$

where

H = theoretical head in feet of fluid (can be in terms of water head)

v_2, v_1 = absolute velocities of exit from and entrance to impeller, respectively

u_2, u_1 = peripheral velocities at exit and entrance of impeller, respectively

w_2, w_1 = relative velocities of discharge from and entrance to impeller, respectively

i_2, i_1 = sensible heat contents per lb. of fluid in B.t.u.

$J = 778$

α_2, α_1 = angle made by vectors of v_2 and v_1 with those of u_2 and u_1

p_2, p_1 = absolute pressures in lb. per sq. in. abs. at exit and entrance, respectively.

Equations [10], [11] and [12] are, if the sensible-heat factor is neglected, well-known standard equations for centrifugal pumps and their derivation as given will be found in any textbook on turbine pumps. The increase in sensible heat is assumed to be that due to adiabatic expansion and friction in the impeller. If there are a large number of stages in the compressor the change in sensible heat per stage, due to adiabatic expansion, can be omitted when using the above equations. That due to friction is a very uncertain quantity and can be approximated only.

The head H is the head which must be imparted to the impeller in order to obtain the actual head H^A; that is, H must cover all pneumatic losses. If we let H_L represent the loss of head due to resistances to fluid flow, etc., and η_p the pneumatic efficiency, then

$$\eta_p = \frac{H_A}{H} = \frac{H_A}{H + H_L} \quad [13]$$

The pneumatic efficiency is analogous to the hydraulic efficiency of centrifugal pumps and is a measure of the pneumatic losses in the compressor. These losses cause a reduction in H due to (a) the frictional resistances offered by the interior surfaces of the machine to the movement of the fluid, and (b) to too abrupt changes in the fluid path both in direction and cross-section.

In calculating the fluid velocities of entrance to and discharge from impeller, it is assumed, as mentioned before, that the fluid particles move through and discharge from the impeller with the same relative positions. In other words, the velocity at any cross-section of the impeller channel is the same for all the fluid particles. Of course, this can only be true for an impeller with an infinite number of blades of infinitesimal thickness. Actually, between any two blades the fluid stream has its maximum velocity at the center of the stream, while those particles adjacent to the blades are retarded in their motion due to the surface drag of the blade surfaces. From a practical standpoint, however, it is sufficient to assume that all the fluid particles have the same velocity as those of the middle filament. Such being the case, the effective radii, r_2, r_1 of the impeller will be different from actual exterior radii R_2 and R_1 (Fig. 6). The entrance- and exit-velocity diagrams should be laid out from the points a and b, Fig. 6. If this is done there results an increase in η_p, bringing it closer to the value desired. Line 1—1 (Fig. 6) is drawn normal to the blade at point 2, while 3—4 is drawn normal to the blade at point 3. Points x are located at the centers of these lines. It should be noted that if the foregoing theory is to be applied with the expectation of good results, the impeller blades at entrance and exit must have relatively small divergence, thus insuring that the velocities across these sections will be fairly uniform.

DIFFUSERS

On discharge from the impeller the energy content of the fluid, as previously shown, is largely in the potential and kinetic form. For a perfect impeller the division between the two would be nearly equal. Actually, however, this is not the case, the potential energy being smaller in value than the velocity energy. That is, the pressure head will be less than the velocity head. In order to convert part of this velocity head into pressure head, use is made of so-called diffusers. These can be made in two forms, the free vortex and the guide vane. As a matter of fact, the second or guide-vane diffuser is really at normal loads a free-vortex diffuser, providing the guide vanes have been properly designed. Of course, this is not the case under ordinary conditions, particularly in a multiple-stage machine where it is desirable that the discharge from the diffuser shall be radial, or at least not far from radial.

On discharge from the impeller a fluid particle, if unhindered, will trace out a spiral path providing the space surrounding the discharge side of the impeller has sufficient radial depth. In other words, the fluid as a whole will have a free vortical motion and it can be shown that the path of any fluid particle is a logarithmic spiral, the equation of which is

$$r = e^{k\theta} \quad [14]$$

where

$e = 2.7183$

k = constant

θ = angle of radius-vector with entrance position.

With free vortical motion of the discharge the maximum possible gain of pressure is as given by one of the equations in the complete paper. Due to instability of flow, friction of side walls, impact, etc., however, which cause the stream lines to be widely divergent from the theoretical, the gain of pressure given by this equation is not attainable in practice. If a free-vortex diffuser is used it is essential that its radial depth be sufficient for the vortical motion to develop and thus secure as large energy con-

version as possible. The axial depth of the diffuser on the entrance side should be the same or slightly greater than that of the impeller discharge. This axial depth may remain constant or gradually diverge from inlet to outlet of diffuser. It is of course quite essential that the inner surfaces of the diffuser shall be as smooth as possible in order that friction shall be eliminated.

Because it is practically impossible to obtain non-turbulent motion in a free-vortex diffuser the use of guide vanes has been introduced. These are located in the diffuser channel and divide it up into several separate sections, through which the fluid can flow with a reduced tendency to become turbulent. As a consequence the conversion efficiency is higher than in the case of the diffuser without guide vanes. In practice it is difficult to transform much more than 50 per cent of the kinetic energy possessed by the fluid on entrance to the diffuser into pressure energy by the time the fluid is discharged. With a guide-vane diffuser the best conversion efficiency is obtained at normal load when the fluid leaves the impeller in such a direction as to enter the diffuser sections with a minimum of shock, eddying, etc.

The number of guide blades should be sufficient to give the desired uniformity of flow without undue friction, usually one-half to two-thirds as many guide blades as impeller blades. If the same number of blades are used in both there may result severe periodic impulses or vibrations due to the fact that the clear cross-section of the fluid channels at discharge of impeller and entrance to diffuser are increasing and decreasing in unison.

Theoretically the shape of the guide blades should be that of a logarithmic spiral to conform with the free path which the fluid tends to follow on leaving the impeller. Actually, the blade shape is governed by other requirements. A favorite form of guide-blade construction is that shown in Fig. 6, and is similar to those used on turbine pumps. The cavity inside the blades is connected with the cooling-water circuit and thus some reduction in the temperature of the fluid is obtained while it flows through the diffuser. The blade curves are customarily volutes or involutes on the entrance side of the diffuser and a combination of circular arcs and straight lines for the remainder of the blade length.

(C) POWER CONSUMPTION AND EFFICIENCY

In order to compete successfully in the industrial field with the reciprocating compressor it is of great importance that the overall efficiency of the turbo-compressor be made as high as possible. That is, the difference between the compressor input (work delivered to the compressor) and output (work obtained from compressor) should be reduced to a minimum. The area of the pv-diagram represents the useful work done in the compressor, but it does not cover the pneumatic, mechanical and volumetric losses. If η_p, η_m, η_v, η_t, are the pneumatic, mechanical, volumetric and overall efficiencies, respectively, then the shaft horsepower must be given by the following expression neglecting the kinetic energy of discharge:

$$\text{Shaft Hp.} = \frac{0.261 \times L \times p_1 v_1}{\eta_t} \times \frac{n}{n-1}\left(\left[\frac{p_2}{p_1}\right]^{\frac{n-1}{n}} - 1\right) \quad [15]$$

where

η_t = varies between 0.55 and 0.65 and equals $\eta_p \times \eta_m \times \eta_v$

L = lb. of fluid compressed per sec.

$p_2 - p_1$ = total pressure rise in the machine in lb. per sq. in. abs.

n = compression exponent and is calculated from an equation given in the complete paper.

The mechanical efficiency η_m is the ratio between the total power actually delivered to the fluid and the shaft or brake horsepower. It is a measure of the power losses, made up of rotation loss (friction between outer surfaces of impellers and the surrounding fluid) and bearing loss or similar losses due to friction between metal surfaces. The rotation loss will vary between 10 per cent and 20 per cent of useful output of the machine, being determined by the density of the fluid, the speed of rotation, and the impeller diameters. For a single impeller it can be calculated very approximately from the following expression:

$$\text{Friction Hp.} = 0.44 \times 10^{-13} \times \delta_m \times N^3 \times D^5 \ldots\ldots [16][1]$$

where

N = r.p.m.

D = impeller diameter in ft.

δ_m = mean density of fluid for the stage.

Equation [16] is based upon experiments with constant-thickness disks in open air. It is readily seen from [16] why it is preferable to employ a large number of small-diameter impellers in place of a lesser number with large diameters. With a given discharge any increase in pressure must be accompanied by either an increase in speed or else an enlargement of the impeller diameter. Since the frictional resistance varies as the speed cubed and the impeller diameter to the fifth power, it is more economical to use high speeds with small impellers.

The volumetric efficiency is, of course, the ratio of the fluid actually delivered by the compressor to that taken into the compressor, and will vary between 96 and 98 per cent, a good average being 97 per cent. Most of this leakage will occur in the last stage between the inlet to that stage and the atmosphere, and is not materially affected by the number of stages.

Under ideal conditions the compression would follow the isothermal curve BM on the pv-diagram, Fig. 3. The compression efficiency will be, when referred to the isothermal,

$$\eta_e = \frac{\text{isothermal work}}{\text{actual work}} = \left(\frac{n-1}{n}\right)\frac{T_1}{T_2 - T_1}\log\frac{p_2}{p_1} \ldots\ldots [17]$$

and will vary between 60 and 67 per cent.

The need of cooling the fluid as it passes through the compressor is emphasized by [17]. The heating of the fluid during compression renders it difficult to obtain efficiencies which are materially better than those attainable with reciprocating machines of modern construction. The amount of heat to be dissipated is more than that due to adiabatic compression since the mechanical energy loss due to short-circuiting, eddy currents, fluid impact, and fluid friction reappears as heat energy stored very largely in the fluid itself. By careful design of the cooling-water passages in the casing and diffusers, and by use of a large number of stages, it is possible to carry off most of this sensible heat. In spite of the use of a water-cooled housing, the temperature rise of the air in some turbo-air compressors has been over 200 deg. fahr., the inlet temperature being in the neighborhood of 70 deg. fahr. In the first few stages the cooling effect is small because of the small temperature difference between the air and the cooling water, but in the later stages the compression approaches very closely to being isothermal, as we already know, and the temperature of the air when discharged will range between 150 deg. fahr. and 175 deg. fahr. for discharge pressures of from 75 to 120 lb. per sq. in. gage.

What the Bureau of Mines has done for the great coal-mining industry, chiefly through investigations at the experiment station at Pittsburgh, Pa., has been published in numerous reports issued by the Bureau. Some of the more important accomplishments have been the development and introduction of permissible explosives for use in gaseous mines, the training of thousands of coal miners in mine-rescue and first-aid work, and the conducting of combustion investigations, aimed at increased efficiency in the burning of coal and the effective utilization of our vast deposits of lignite and low-grade coal. How vast are the deposits of low-grade ores being made available through the experiment stations is shown by the work assigned to the station at Minneapolis, Minn. The primary purpose of this station is to devise methods of utilizing low-grade iron ores. It has been estimated that the reserves of low-grade magnetic iron ores in Minnesota alone amount to some forty billion tons, but until recently these ores have been untouched because no process of treating them profitably has been devised. The Minneapolis station has already demonstrated that one process for utilizing the great deposits of manganiferous iron ore on the Cuyuna Range is metallurgically possible.

[1] See pp. 220 and 223, Bulletin of the Bureau of Standards, vol. 10, on Windage Resistance of Steam-Turbine Wheels.

Self-Supporting Chimneys to Withstand Earthquake

Nature of Stresses Developed by Seismic Shocks; Theory of Design of Chimneys to Withstand Such Stresses; Particulars Regarding Chimneys in Which Theory Has Been Applied

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The studies of the Japanese Imperial Investigation Committee on the nature of the stresses developed in chimneys in consequence of earthquakes are summarized by the author, who also examines the conclusions of the committee in the light of data on failures of chimneys secured from inspections of wrecks caused by the San Francisco earthquake of 1906. An advancement to the theory developed by Professor Omori, Chairman of the Japanese Committee, on the design of chimneys to withstand earthquakes, is then presented. This assumes that the chimney, instead of being looked upon as rigid, should be considered as a body oscillating about the center of percussion. Reference is made in the paper to the design of various chimneys where the theory outlined has been applied.

BECAUSE of the prevalence of earthquakes in Japan, and the immense damage resulting from them to buildings and other structures, the Japanese Government, a number of years ago, created the Imperial Earthquake Investigation Committee with a view to having it undertake a scientific study of earthquake phenomena, as well as of the effect of earthquakes on structures, etc. The Committee's reports would fill a good-sized volume. Many of these have been translated into English, and are obtainable at a few of the leading libraries in this country. Professor Omori, chairman of this committee, is the world's greatest authority on earthquake problems.

Although this subject is one of more or less academic interest, there are, however, certain localities in this country, mainly on the Pacific Coast, and many foreign localities, where the design of structures necessitates a careful consideration of the forces due to earthquakes. With the increasing tendency to invest American capital in foreign countries, American engineers will be required to design structures to withstand earthquakes.

A brief review of the work of Professor Omori, together with certain data pertaining to the San Francisco earthquake of 1906, a discussion of what the writer believes to be a limitation in a portion of Omori's work, and also an advancement in the theory of the design of chimneys to withstand earthquake are presented in this paper.

Earthquakes are due to various causes, the principal one being a slippage of the crust of the earth along fault lines. Earthquakes, of course, vary from mild trembles, barely perceptible and lasting but a few seconds, to violent shocks lasting several minutes and capable of demolishing very substantial structures. The principal movement is in a horizontal plane, but the vibration occurs in a number of directions in the same plane. There is generally a slight, but sometimes a severe, movement in a vertical direction, and also a severe twisting effect. On account of the combination of horizontal and vertical motion, earth waves visible to the eye frequently occur during earthquakes.

Earth movements are recorded at most astronomical observatories by means of seismographic instruments which record the displacement of the earth in three coördinates by measuring the amplitude, frequency, and duration of the earth wave.

By means of various earthquake records, values have been established for the maximum rate of acceleration of an earth particle, the maximum amplitude of an earth particle during a complete vibration, and the time for the complete period of vibration; and from these data it is possible to estimate approximately the stresses and strains in simple structures subject to earthquake shock. A sufficient number of earthquakes have been recorded and classified during recent years to make known the maximum intensity of shock experienced in certain localities, and the best that an engineer can do is to design a structure based on recorded experience. There will, however, always be the doubt as to whether some future earthquake may not be more severe than those which have been recorded in the past.

The most severe earthquake recorded in Japan was the Mino-Owari great earthquake of 1891, for which Omori gives the following estimates:

Displacement of an earth particle	233 mm.
Complete period of the principal motion, being a wave cycle	1.3 sec.
Duration of earthquake	4 min. 30 sec.
Maximum acceleration observed at different localities ranged from	3,000 to 10,000 mm. per sec. per sec.

For the purpose of classifying various earthquakes Omori has devised an absolute scale of earthquake intensities as follows:

The following absolute scale of destructive earthquakes, or the relation between the maximum acceleration of the earthquake motion and the damage produced, has been deduced chiefly from analysis of the Mino-Owari earthquake, the intensity being arbitrarily divided into seven classes. It is to be noted that the scale applies principally to Japan.

1 Maximum acceleration, 300 mm. per sec. per sec. The motion is sufficiently strong to cause people generally to run out of doors. Brick walls of bad construction are slightly cracked; plasters of some old dozo (godowns) shaken down; furniture overthrown; wooden houses so much shaken that cracking noises are produced; trees visibly shaken; waters in ponds rendered slightly turbid in consequence of the disturbance of the mud; pendulum clocks stopped; a few factory chimneys of very bad construction damaged.

2 Maximum acceleration, 900 mm. per sec. per sec. Walls in Japanese houses are cracked; old wooden houses thrown slightly out of the vertical; tombstones and stone lanterns of bad construction overturned, etc. In a few cases changes are produced in hot springs and mineral waters. Ordinary factory chimneys are not damaged.

3 Maximum acceleration, 1200 mm. per sec. per sec. About one factory chimney in every four is damaged; brick houses of bad construction partially or totally destroyed; a few old wooden dwelling houses and warehouses totally destroyed; wooden bridges slightly damaged; some tombstones and stone lanterns overturned; shoji (Japanese paper-covered sliding doors) broken; roof tiles of wooden houses disturbed; some rock fragments thrown down from mountain sides.

4 Maximum acceleration, 2000 mm. per sec. per sec. All factory chimneys are broken; most of the ordinary brick buildings partially or totally destroyed; some wooden houses totally destroyed; wooden sliding doors and shoji mostly thrown out of the grooves; cracks 2 or 3 in. in width produced in low and soft grounds; embankments slightly damaged here and there; wooden bridges partially destroyed; ordinary stone lanterns overturned.

5 Maximum acceleration 2500 mm. per sec. per sec. All ordinary brick houses are very severely damaged; about 3 per cent of the wooden houses totally destroyed; a few tera, or Buddhist temples, thrown down; embankments severely damaged; railway lines slightly curved or contorted; ordinary tombstones overturned; ishigaki, or masonry walls, damaged here and there; cracks 1 or 2 ft. in width produced along river banks; waters in rivers and ditches thrown over the banks; wells mostly affected with changes in their waters; landslips produced.

6 Maximum accleration, 4000 mm. per sec. per sec. Most of the tera, or Buddhist temples, are thrown down; 50 to 80 per cent of the wooden houses totally destroyed; embankments shattered almost to pieces; roads made through paddy fields so much cracked and depressed as to stop the passage of wagons and horses; railway lines very much contorted; large iron bridges destroyed; wooden bridges partially or totally damaged; tombstones of stable construction overturned; cracks a few feet in width formed in the ground, accompanied sometimes by the ejection of water and sand; earthenware buried in the ground mostly broken; low grounds, such as paddy fields, very greatly convulsed, both horizontally and vertically, sometimes causing trees and vegetables to die; numerous landslips produced.

[1] Chief Engineer, Chas. C. Moore & Co. Engineers. Mem.Am.Soc.M.E.

7 Maximum accleration much above 4000 mm. per sec. per sec. All buildings, except a very few wooden houses, are totally destroyed; some houses, gates, etc., projected 1 to 3 ft.; remarkable landslips produced accompanied by faults and shears of the ground.

In the above scale of the seismic intensity, the earthquake motion has been assumed to be entirely horizontal. This supposition would not, except in places very near to the epicenter, cause sensible errors in the result.

A complete report was made of the San Francisco Earthquake by the California Earthquake Commission. This report, which has been published by the Smithsonian Institute, gives numerous charts, diagrams, photographs along fault lines and of wrecked structures, etc., and its study will be of value to any one desiring to pursue this subject further.

Seismographic records were almost valueless for the San Francisco earthquake because practically all of the instruments at the local observatories were put out of commission by the intensity of the shock, the full amplitude greatly exceeding their limits of movement. Omori visited San Francisco soon after the earthquake and, judging from the damage done, estimated the complete amplitude of the most severe shock to have been about 4 in., and the complete period of vibration of an earthquake wave about 1 sec. He also noted shear along the fault lines at different points from 16 to 20 ft.

Professor Lawson, a member of the California Earthquake Commission, estimated, from the Omori scale, that the acceleration for various formations in San Francisco had been as follows:

Foundation	Acceleration mm./sec.²
Serpentine	250
Made land	1100
Marsh	3000
Sandstone	250 to 600
Made land	2900
Sand	600
Sandstone	400
Sand (Mission Valley)	1100
Marsh	3000
Sundry solid rocks	250

It will be noted from these data that earthquake shocks are least severe on structures built on rock foundations and most severe on structures built on loose or filled ground.

Omori discusses the force due to earthquake as impulsive or gradual, defining the former as a force applied to an elastic body so rapidly that it is finished in a time interval infinitely small in comparison to the period of natural vibration of the body, and the latter as a force applied so slowly that the body assumes a position of equilibrium without being thrown into vibration.

Within moderate limits of intensity of earthquake shock, Omori shows that structures are likely to fail which have a natural period of vibration materially less than the period of the earthquake, and structures are not likely to fail which have a natural period of vibration equal to, or greater than, the period of the earthquake. It is apparent that structures in the former class are short in comparison with their width, or diameter, and, until failure occurs, are accelerated throughout their mass by the earthquake vibration, inducing stresses resulting from the acceleration of the mass of the structure as a whole. Structures of the latter class are generally tall in comparison with their width, are more or less flexible, and, owing to their natural period of vibration with respect to the earthquake period of vibration, are able to yield in a measure to the earth movement, and are not accelerated as a whole at a rate equal to the earth's acceleration, and, consequently, are stressed to a less extent than in more rigid structures.

Omori brings out the well-known proposition that a force impulsively applied to an elastic body produces a stress double that caused by the same force when gradually applied, and further states that since brick fractures immediately the limit of elasticity is exceeded, the strength of a brick column against a force implied impulsively is half that against the same force applied gradually.

Having reduced the investigation of earthquakes to a basis of numerical acceleration and stated periods of vibration, Omori proceeds to show that for any given structure, such as a vertical prism resting on its base, the force necessary to accelerate the mass is to be computed from the well-known formula that the force is equal to the total mass of the structure, multiplied by the acceleration, divided by g; assuming, of course, that the mass is accelerated as a whole. This force may be considered as applied at the center of gravity, and it exerts a turning moment at the base of the prism equal to the computed force multiplied by the height of the center of gravity above the base.

In one of his reports Omori gives the results of investigation of forty-nine self-supporting brick chimneys. These failed at points from 24 per cent to 94 per cent of the height of the chimney, the average failure being at a point about two-thirds of the height of the chimney, while practically none of the chimneys failed at the base. He points out that the point of failure corresponds approximately to the center of percussion of the chimney with reference to a horizontal axis at the base of the chimney. Unfortunately, no self-supporting steel chimneys nor reinforced-concrete chimneys were in existence in Japan during the severe earthquake shocks of 1891 and 1894.

Omori shows that the failure of chimneys at the center of percussion instead of at the base of the chimney indicates a tendency to oscillate, as it were, about the center of percussion. There is a whip-snapping effect of the upper portion of the chimney which may cause a condition of resonance. In chimneys which have failed portions of the top of the chimney have been thrown down, striking the ground never at a great distance from the base of the chimney.

The writer investigated the failures of a number of chimneys in the San Francisco earthquake of 1906, and found that brick chimneys failed in about the same manner as observed by Omori. The tallest chimney investigated was 240 ft. in height, and failed at a point about two-thirds its height. Many of the large brick chimneys in the San Francisco District failed, although a few on rock foundation and especially well built did not fail by having a portion of the chimney height demolished; but the chimneys that did not suffer in this way were at least cracked either vertically or horizontally.

There were no reinforced-concrete chimneys in San Francisco at the time of the earthquake, and but one large self-supporting steel chimney, this being 10 ft. in diameter by 120 ft. in height. This chimney, although brick-lined, was not injured by the earthquake. A 150-ft. self-supporting steel chimney at the Mare Island Navy Yard was uninjured by the earthquake. A 217-ft. brick-lined self-supporting steel chimney at Salinas, Cal., likewise was uninjured by the earthquake.

Omori made an interesting series of experiments with brick columns on a shaking table, duplicating in effect earthquake motions of varying intensities. The results of these experiments are too elaborate for presentation in this paper. They showed conclusively that estimates of the tensile strength of brickwork are exceedingly uncertain and undependable, owing to the variation in the character of workmanship in laying the brick.

Omori has measured the natural period of vibration of a number of self-supporting brick chimneys. One chimney 50 ft. in height was found to have a natural period of vibration of about one second.

Recently a very tall concrete chimney has been erected in Japan for the Kuhari Mining Co., Saganoseki, in the Oita Prefecture, Kyushu. The main shaft has a height of 550 ft.; the inside diameter at the top is 23 ft. 6 in.; the base is circular and 95 ft. in diameter; the natural period of complete vibration of the chimney was observed by Omori to be 2.5 sec. The range of motion or double amplitude of the top of the chimney was 1 in. at a strong gale of 24 m. per sec., but it reached 7.7 in. at a hurricane wind blowing 35 m. per sec. The chimney is located on hard rock, on which it is estimated an earthquake movement would be comparatively weak, probably having an intensity of less than 500 mm. per sec. per sec. A 100-ft. reinforced-concrete chimney 3½ ft. inside diameter at the top was found to have a period of vibration of 0.8 sec.

Some interesting observations of a chimney at Providence, R. I., are given by Dr. D. S. Jacobus, in his paper on Counterweights for Large Engines.[1] The stack was built on a mass of concrete

[1] Trans. Am. Soc. M. E., vol. 26 (1906), p. 531

which extended under the building structure. Referring to the vibration of the chimney due to the reciprocating engine, Dr. Jacobus states:

> At a point near the extreme end of the foundation where the No. 1 engine was located the foundation was found to shake 0.008 in. Measurements made near the top of the chimney, which was erected to the height of about 175 ft. above the ground, showed that the maximum shake with the engine running at its ordinary speed of 90 r.p.m. was about 0.02 in. After measuring the vibration of the chimney with the engine running at its ordinary speed the engine was shut down and a marked result took place when its speed fell in harmony with the time of vibration of the chimney. When this occurred, the chimney shook to such an extent that the motion was beyond the range of the special instrument. The total movement of the pointer of the instrument was such that the chimney was shown to move more than one-eighth of an inch. In constructing the chimney the workmen had noticed that when they came to a height of about 130 ft. the vibration was much greater than it was after the chimney was built higher. This made it appear that at the height of 130 ft., at which there was the most shake, the time of the vibration of the chimney was in harmony with the number of revolutions made by the engine.

Professor Omori has also collected many data with respect to the effect of earthquakes on bridge piers.

Following the San Francisco earthquake and fire the city of San Francisco installed an elaborate high-pressure fire-fighting system, including two high-pressure salt-water pumping plants; the structures were designed to withstand earthquakes by utilizing the latest information obtainable from the San Francisco Earthquake Commission, an acceleration of 6.2 ft. per sec. per sec. being stipulated. Pumping plant No. 1 included four chimneys specified not to exceed 90 ft. in height, to minimize the earthquake risk, and measuring 64 in. inside diameter at the top. These chimneys were finally made of reinforced concrete and self-supporting.

As the writer's firm undertook to build a substantial part of this pumping plant he engaged a local engineer of prominence to make a special design of chimney to withstand earthquakes, and in the course of the next few years several other chimneys were designed in the same way. These designs followed Omori's theory, as outlined above; the bending moments due to earthquake were calculated for all sections, assuming the lateral displacement of the chimney to result from the earthquake acceleration imparted to the mass of the structure as a whole and the chimney shaft to remain vertical at all times. This theory gave a strength of chimney at the base materially greater than at the higher sections, and in view of Omori's observation of the frequency of breakage at two-thirds of the height, the reinforced amount was empirically increased at this section. No severe earthquakes have tested the accuracy of the design. Recently the writer had occasion to examine the subject further in connection with the erection of a chimney 220 ft. in height and 14 ft. in inside diameter at the top.

The chimney in question was constructed during the war time, and on account of the prohibitive price of self-supporting steel chimneys, decision was made in favor of reinforced concrete.

The writer concluded that while the chimney might have a tendency to sway somewhat about the base as an axis, the principal design should be made on the basis of accelerative rotation of the chimney about its two-thirds point, instead of a motion of accelerated translation parallel to itself, as heretofore assumed. The theory of rotation harmonizes with the observed failures of chimneys, whereas the theory of translation does not.

Considering the chimney as a rigid body and assuming the two-thirds point to be at rest and the acceleration of the earth to be known, then the angular acceleration about the two-thirds point becomes immediately known, and from the principles of moment of inertia the bending moment at different sections is easily computed. Such theory, however, would only apply if the chimney were under no strain at its base or foundation. If such rotation did exist, the chimney remaining rigid, then there must occur either a yielding of the soil under the chimney foundation, or a deflection or fracture of its base, or both. An investigation of the foundations of chimneys which had failed in the San Francisco earthquake did not lend support to this theory, and the writer finally concluded that the element of flexibility of the chimney shaft played a most important part in chimney design.

A further important consideration in chimney design is the deflection of the chimney from the base to its neutral point, assumed to be at two-thirds of its height. It is only on the assumption that a tall chimney will deflect within its elastic limit one-half the amount of the earth's vibration that its stability during a severe earthquake can be maintained without rupture.

The failure to find serious horizontal cracks near the base of the shaft or in the foundation of some large self-supporting brick chimneys can only be explained on the theory of deflection. This theory is not touched upon by Omori in any of his reports.

Fortunately it is comparatively easy to make an approximate estimate of the elastic deflection of a self-supporting chimney, but unfortunately the writer is not able to indicate the factor of safety to be applied to this deflection as compared with the earth's vibration.

The writer consulted E. P. Lewis, Professor of Physics, University of California, who submitted a statement as follows:

> Since seeing you I have considered the questions raised in the memorandum which you gave me regarding the design of chimneys. As I told you, the problem seems so complex, and the factors so obscure, that I can do no more than make some suggestions regarding the physical principles involved.
>
> In the first place, referring to Omori's view that the center of percussion of the chimney remains at rest under the impulse of an earthquake, Omori evidently makes this assumption by considering the case of an impulse at one end of the uniform rod on which no other forces act. In this case the center of percussion is a fixed axis of rotation, as is easily shown by considering that the resultant moment of momentum, due to the impulse, must vanish if taken about the point at which the impulse is applied. In the case of the uniform rod this is one-third the length of the rod from the opposite end. I think, however, that Omori's assumption is incorrect. The above applies to a body free from external forces after the application of the impulse, whereas the chimney remains fixed to its base, and the principle applies to a perfectly rigid body, which the chimney is not.
>
> As a matter of fact, I am confident that something like this happens: The impulse comes along; an elastic wave runs up the chimney; during its first passage the center of percussion has a minimum motion; the earth movement ceases; the inertia of the chimney carries it forward until it is brought to rest by elastic reactions, which cause it to vibrate in the opposite direction, and any effect at the center of percussion vanishes. The amplitude of the motion of the top of the chimney (ventral segment of the vibration) probably is many times greater than that of the earth. If the earth vibrations are approximately synchronous with those of the chimney, the amplitude may become very great; if the frequency of the earth vibration is three times that of the chimney, "overtones" will appear with a nodal point one-third of its length from the top of the chimney (if of uniform section), thus adding to the possible effect due to the center of percussion.
>
> A wooden or glass rod clamped to a massive base, which is then subjected to a shock or vibration, behaves as I have indicated above, and I am sure that a tall chimney behaves in qualitatively the same way.
>
> I think you are right in considering that the vibratory motion of the chimney is of fundamental importance, and that account must likewise be taken of vertical displacements. Below [See Fig. 1] I sketch some of the phases of the motion of the chimney as I imagine it.
>
> It occurs to me that especially violent effects might occur if succeeding non-periodic shocks come at such phases of the chimney vibration due to the first shock as to suddenly increase the acceleration.
>
> I have given my ideas so far as they are clear to me. I do not speculate further because the problem is so difficult and obscure that I might easily suggest some error.

The sketches submitted by Professor Lewis are shown in Fig. 1. At *a* is shown a vibrating rod, fixed at the base, in its initial position; at *b* the effect of the center of percussion; at *c* the effect when the center of percussion vanishes; and at *d* the effect of a three-to-one overtone.

The ordinary chimney having much less flexibility than the experimental rod considered by Professor Lewis, it is the writer's opinion that the extreme effects which Professor Lewis mentions would not be experienced by a chimney with intensity of shock equal to that of the San Francisco earthquake.

In completing the design of the chimney in question, it was necessary for the writer to make certain assumptions, as follows:

1 That the minimum strength at any section must be equal, of course, to that required to withstand wind pressure; that an earthquake would not occur at a time of the hurricane wind velocity for which the chimney is designed; and that the addition of these forces would be unnecessarily conservative.

2 That the minimum strength at any section to withstand earthquake, should correspond to the equal acceleration of the chimney as a whole, considered as a rigid body, the axis of the chimney remaining vertical at all times; due to its flexibility, the chimney is not accelerated equally throughout, so that the writer assumed that this calculated moment should not be doubled, as customary for vibration.

3 That the minimum strength at any section to withstand earthquake should correspond to that required for the angular acceleration of the chimney about the center of percussion, as explained above; allowance being made for the doubling of stresses due to the vibratory or whip-snapping action of the chimney; a factor of safety must still be applied on account of the uncertainty of such calculations, as further outlined below.

4 That the vertical acceleration of the chimney should be considered as resulting from the vertical component of the earth wave. The stress computed in this manner will be generally found to be very small.

5 That in the case of reinforced-concrete chimneys the temperature stresses must be computed for temperatures correspond-

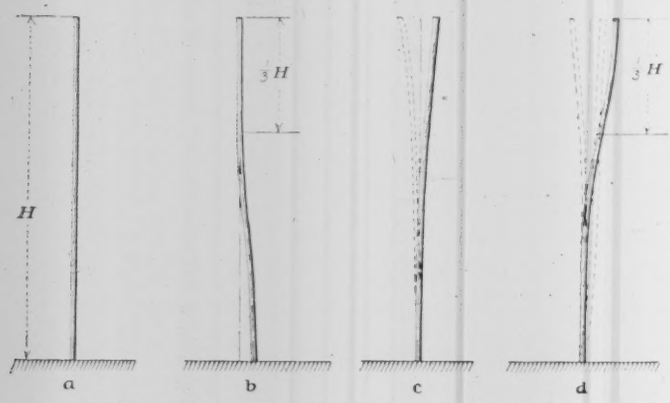


FIG. 1 VIBRATIONS OF AN ELASTIC ROD FIXED AT ITS BASE

a Initial position. *b* Effect of center of percussion. *c* Effect when center of percussion vanishes. *d* Effect of a 3:1 overtone.

ing to the average overload on boilers, and this condition should be assumed as being coexistent with a possible earthquake, the temperature stresses being added to earthquake stresses.

6 That the foundation or base of the chimney should be very carefully investigated with respect to the moments produced at the base of the chimney by the earthquake, and transmitted through the foundation.

7 That the elastic deflection of the chimney through its two-thirds height, measured from the base, should be somewhat greater than the amplitude of an earth particle, the amplitude being taken as half the total movement of an earth particle.

As a check on the above theory of design, investigation was made along parallel lines of the brick-lined self-supporting steel chimney of the Spreckels Sugar Company, at Salinas, Cal., details of which are here reproduced, with the permission of the Spreckels Sugar Company, in Fig. 2. This chimney was erected in 1897, and was presumably designed to withstand wind pressure only. Having an inertia effect comparable with the chimney under consideration, and having successfully withstood the action of an earthquake of intensity approximately the same as that estimated for the reinforced-concrete chimney, it afforded a standard of comparison for testing the computed strength of the reinforced-concrete chimney. For any section, the ratio of the assumed elastic limit of the steel to the computed tensile stress, according to the above theory, gave a factor in all cases greater than unity, indicating either that, if the above theory is correct, the earthquake intensity could have been multiplied by this factor before the elastic limit of the steel would have been reached; or that the whip-snapping and inertia effects, due to earthquake, resulted in stresses greater than calculated, by a ratio numerically equal to this factor.

If the factor were not applied it does not necessarily follow that the reinforced-concrete chimney would be unsafe. It may, and probably does, indicate that the strength of the Spreckles chimney was somewhat greater than required to withstand the San Francisco earthquake.

The factors of safety, mentioned under [3], finally used, were as follows: Starting with a factor of 1 at the 20-ft. section (measured from the ground line) these factors were gradually increased up to 2.5 at the critical section, or two-thirds of the height, and this factor was continued to the top of the chimney. The amount of steel required for this increased safety in the upper or critical sections was relatively small and inexpensive.

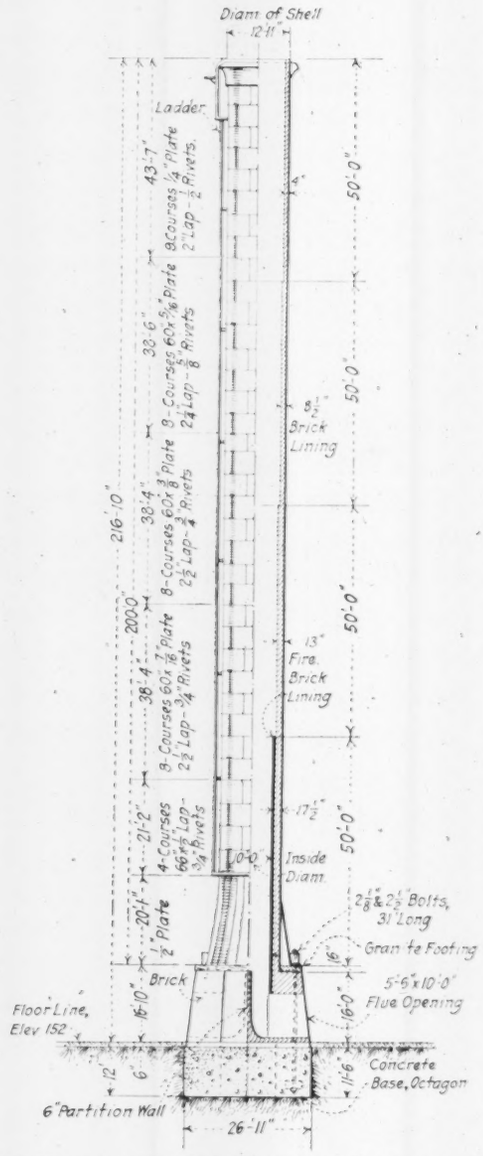


FIG. 2 SELF-SUPPORTING STEEL CHIMNEY, SPRECKELS SUGAR CO., SPRECKELS, CAL.

On the other hand it seemed the part of wisdom to apply to the chimney such factors as would produce a stability against earthquake approximately equal to that of a chimney which had withstood earthquake shock.

Experience extending over a long period of time will alone indicate the proper factors to be applied in chimney design in order to insure the structure against earthquake acceleration. This, for the reasons stated above, was impossible in San Francisco. According to Omori, fifty years may elapse before another severe shock; the preceding one was in 1868.

The method used in computing the temperature stresses in the

(*Continued on page* 204)

Electric Power Supply of Southern Textile Mills

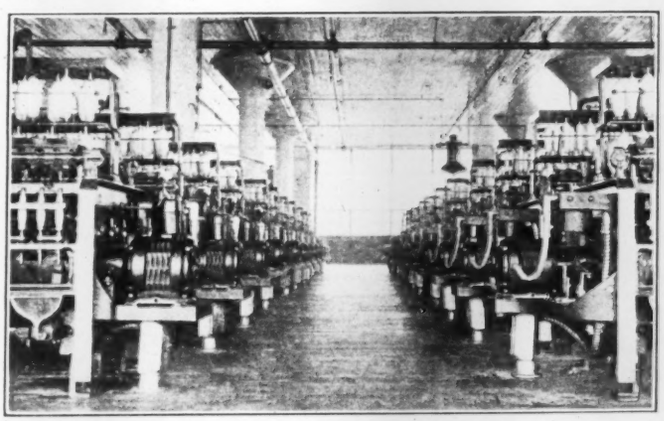
By J. E. SIRRINE,[1] GREENVILLE, S. C.

IN that section of the South comprising the Carolinas, Georgia, Alabama, and Tennessee there are 840 cotton mills manufacturing cloth and yarn and 310 cotton knitting mills. Fifty-seven per cent of these plants are operating on purchased electric power and consume approximately 700,000,000 kw-hr. annually. In twenty years the number of mills has increased 311 per cent; and in the past ten years alone this increase has been 43 per cent. The present annual consumption of cotton is now 3,100,000 bales, or approximately 30 per cent of the entire amount grown in America.

The earlier textile mills were naturally located at water-power sites, and they accordingly suffered from lack of transportation facilities, access to labor markets and damage by flood. Transmission in these mills was entirely mechanical. The development of steam power made possible the more advantageous placement of the mills on transportation routes and in communities capable of supplying labor. These steam-driven mills were at first developed with mechanical transmission, and this equipment was developed to a high degree of perfection along well standardized lines.

The development of alternating current and the commercial production of the induction motor provided a new type of transmission which was quickly adopted, and complete mills were equipped throughout with these motors in the early 90's. It is interesting to note that some of the original motors are still in successful operation and giving first-class service.

The first textile mill to use transmitted electric power was probably the Columbia Duck Mill, in Columbia, S. C. At this plant the power was simply transmitted a few hundred feet from the generating plant on the power canal to the mill on the



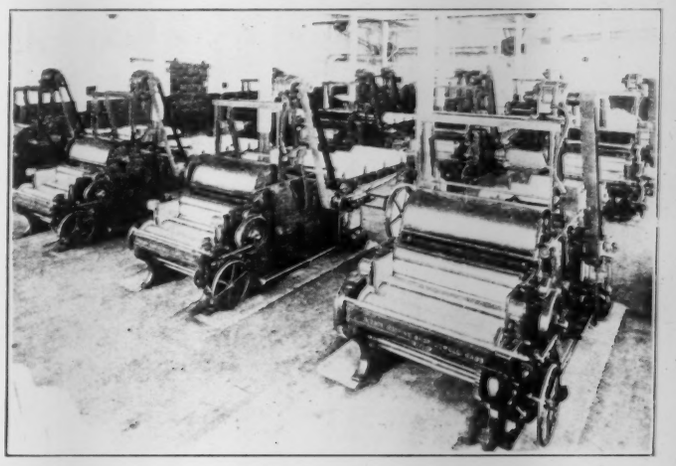
TYPICAL INSTALLATION OF SPINNING FRAMES EQUIPPED WITH INDIVIDUAL MOTORS

hill. Following this came the Pelzer Manufacturing Company's installation where power was transmitted for approximately four miles at 3,500 volts and stepped down at the mill to 230 volts. These were both isolated plants. Probably the first commercial generating and transmitting project was the Portman Shoals plant of the Anderson Water, Light & Power Company, at Anderson, S. C. In this plant the power was generated at 10,000 volts and transmitted at this voltage to the Orr and other mills in the city of Anderson, S. C.

As the advantages of electric-motor drive became more generally recognized other companies were developed for the generation and transmission of electric power, and there are now approximately twelve large companies in the territory, with an interlocked network of transmission lines practically covering it. The hydraulic generating plants have an aggregate capacity of 500,000 kva., and in connection with these plants are operated steam auxiliary stations with a capacity of 150,000 kva., making a total developed capacity of 650,000 kva. The power companies own undeveloped water power sites with an aggregate probable capacity of 450,000 hp.

The hydroelectric developments utilize moderate heads, ranging from 12 to 580 ft. and averaging 40 to 60 ft. Storage reservoirs are being built on some of the streams to conserve the seasonal flow. In several cases a number of plants are built on the same stream and successive use of the water is obtained.

The steam auxiliary plants are now built with first-class construction throughout, and employ the best equipment and mechanical saving devices. In some of the earlier plants the mistake was made of depending on cheap and ample labor, factors which no longer exist.



A TYPICAL PICKER ROOM WITH INDIVIDUAL MOTOR DRIVE

The main transmission lines are usually designed for operation at 60,000 or 110,000 volts, and these lines are carried on steel towers. As a rule, twin circuits are used on the more important lines. For branch lines, voltages of 10,000, 22,000 and 40,000 are generally employed, and the circuits supported on wooden poles. All the standard systems are 60-cycle, 3-phase, so that interconnection and exchange of power between the companies is readily carried out.

The general map of the territory, page 162, shows the principal trunk transmission lines. It should be noted that there is a continuous trunk which can be interconnected from Goldsboro in the eastern part of North Carolina to Nashville in middle Tennessee, a distance by air line of 500 miles and by transmission line of 720 miles. This is equivalent to a transmission line between Bangor, Maine, and Philadelphia, which would serve the industrial territory lying between these cities.

There are two classes of electric power sold in the territory, one known as primary power, which is guaranteed for continuous supply, barring accidents; the other, known as secondary power, is furnished only when there is sufficient water in the streams to generate it, and when the power company cuts off this class of power, the mill plants are compelled to generate this power locally with prime movers.

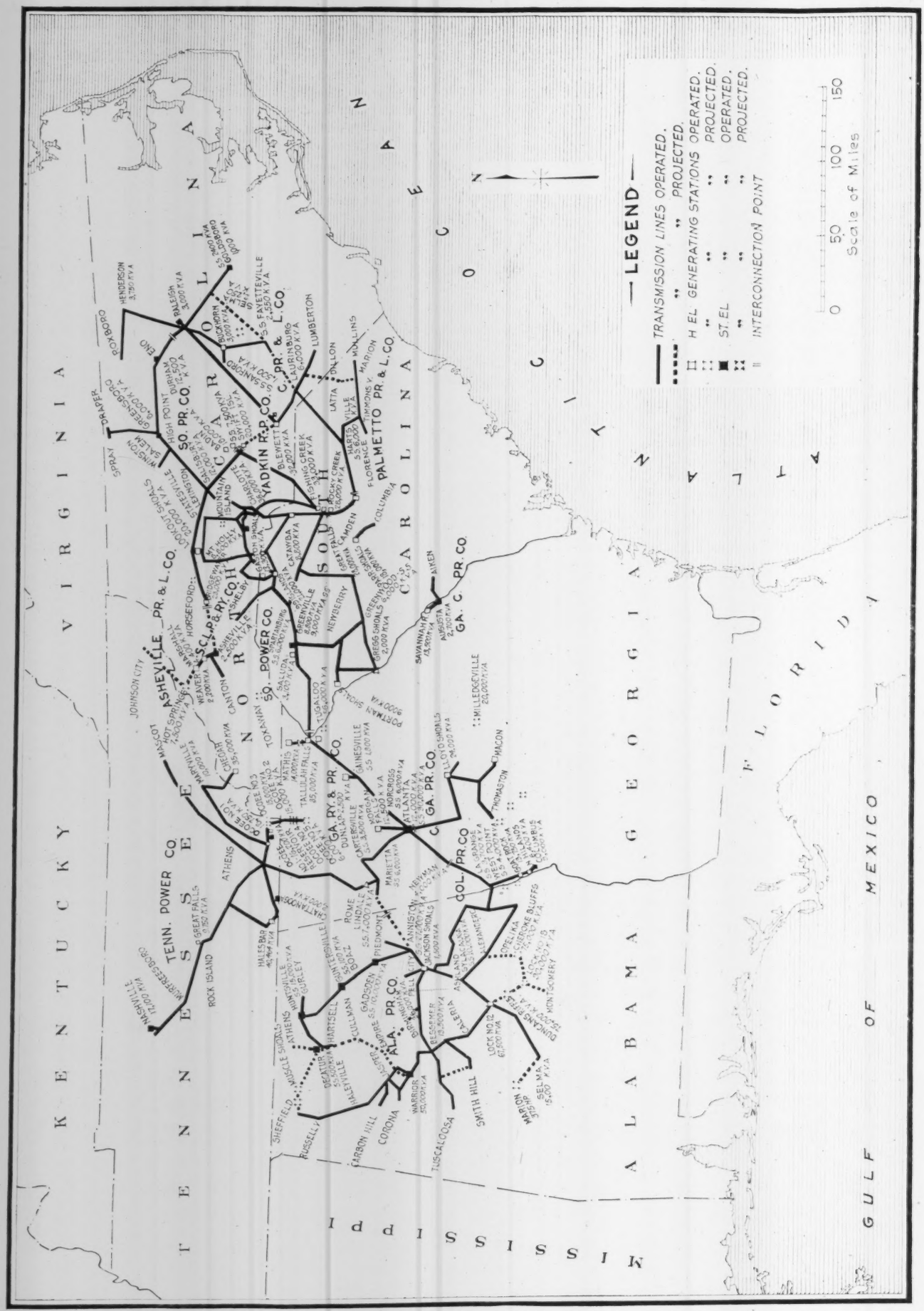
The cotton mills give a steady all-day load which is highly desirable from the central-station standpoint. The maximum peak occurs at the starting hour in the morning when the machinery is cold. This peak is about 10 per cent above normal. The rest of the day the load is practically uniform.

At the mills the transmitted power is usually stepped down to 550 or 220 volts, and at these lower voltages is distributed throughout the plant.

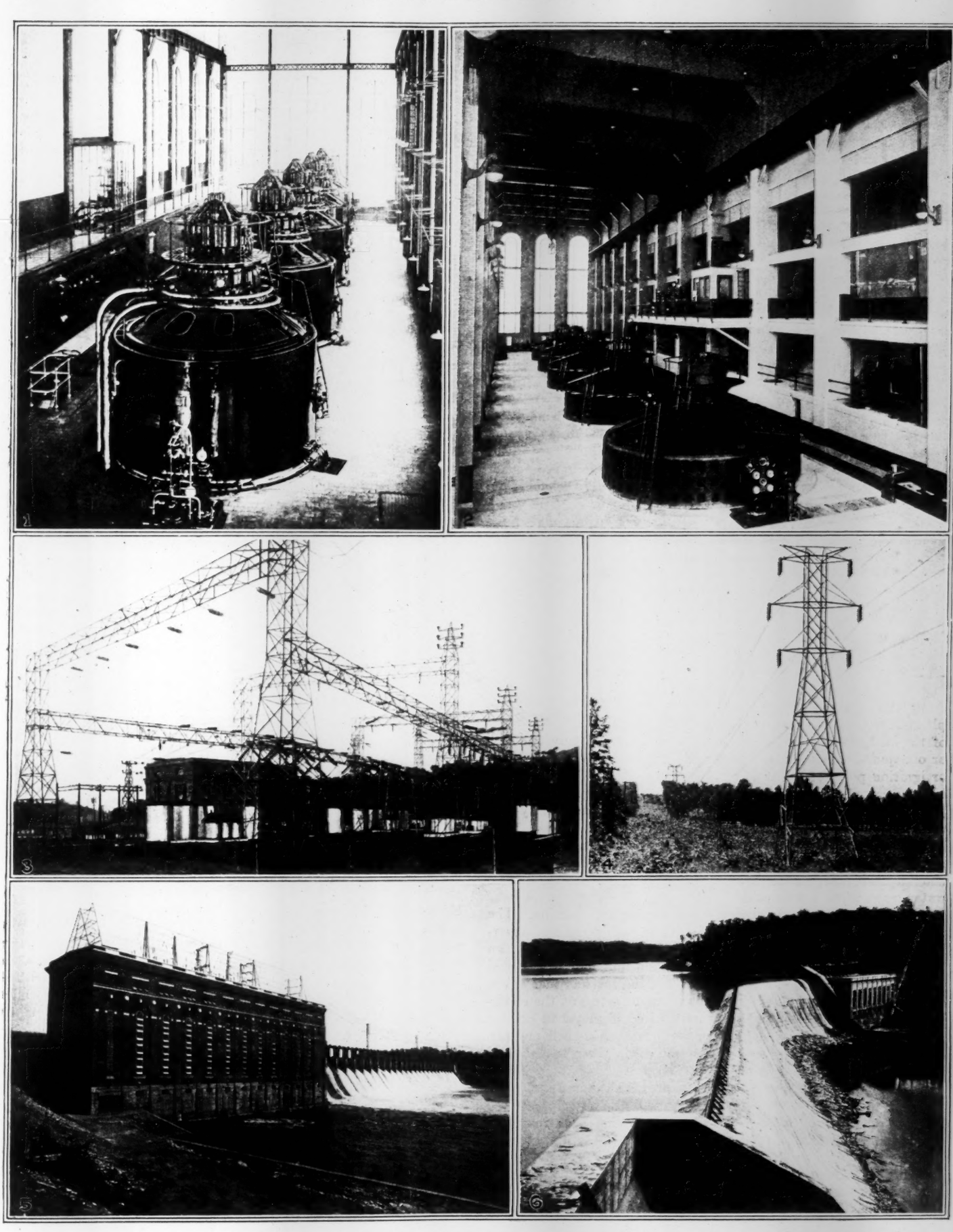
(Continued on page 205)

[1] Mill Engineer and Architect.

Presented at the Annual Meeting, New York, December, 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. All papers are subject to revision.



THE PRINCIPAL ELECTRIC TRANSMISSION LINES OF THE SOUTH



SOME TYPICAL EXAMPLES OF ELECTRIC POWER GENERATION AND DISTRIBUTION IN THE SOUTH

Fig. 1—Generator Room in the Georgia Plant of The Georgia Railway and Power Company; Fig. 2—Generator Room in the Coosa River Power House (Lock No. 12) of the Alabama Power Company; Fig. 3—40,500-kva. Distributing Station of the Alabama Power Company; Fig 4—110,000 Volt Transmission Lines of the Alabama Power Company; Fig. 5—Lock No. 12, Coosa River—Alabama Power Company; Fig. 6—Lookout Shoals, North Carolina—Southern Power Company.

The Proper Balancing of Fuel, Lubricant and Motor

A Study of the Dilution of Lubricating Oils in Aeronautic and Automobile Engines by the Gasoline Mixture and the Resulting Losses of Fuel, Power and Lubricant

By WILLIAM F. PARISH,[1] CHICAGO, ILL.

Dilution of motor lubricating oil has always existed; this condition is caused by the gasoline mixture escaping past the piston rings, with a possible secondary cause—drainage of the diluted oil from the cylinder walls.

In the earlier years of highly volatile gasoline the gas escaping past the piston rings did not enter extensively into the body of the lubricating oil, and while mechanical losses of fuel took place in all four-cycle engines, this loss did not reflect itself in a problem of dilution. In the past few years, however, due to the heavy end components of the fuel, a larger amount after passing the rings, upon condensation, remained in the lubricating oil, thus creating a condition of dilution.

Not until the period of high-end-point gasoline did the matter of fuel loss become apparent, and then only in proportion to the amount held in solution in the lubricating oil. This condition, which has become especially accentuated in the past three or four years, has resulted in undue wear upon the engine parts as well as affecting the use of fuel, lubricant, and power.

The purpose of this paper is to call attention to this underlying trend in the situation and to suggest a method of application of motor oils to correct some of the present faults. It is felt that a true solution can be reached only in changes in mechanical equipment of the engine, and a plea is made for better engine design and greater economy in the use of gasoline and lubricating oils.

DURING 1911, in conducting research work in connection with the use of various fuels and lubricant on a four-cylinder automotive engine and in examining the lubricating oils before and after use, it was noticed that the oil drawn from the crankcase after use had undergone a considerable physical change, the most noticeable thing being that the viscosity of the oil had been lowered during use until it was only one-half or one-quarter as much as the viscosity of the new oil. The flash or ignition point of the used oil was only a third of the original, in some cases being lowered from 470 deg. to 150 deg. fahr. Other just as remarkable changes had taken place in the gravity and cold test of the oil.

The automotive engineers who made the tests stated they had always noted a similar condition in the case of racing cars where, after a hard race, the oil drawn from the engine was as thin as water, even when it was cold.

Technical records were searched for similar information. The only reference regarding the lowering of the flash point and lowering of the body of the oil in automotive engines was found in an English paper, which stated that this condition had been noted but that no solution had been found. The matter was then taken up with the most prominent automotive manufacturers, the condition explained to them, and they were asked if they had noticed the changes that had taken place in the lubricant in their engines. Practically the only answer was that the oil in these engines had worn out and become thin.

An article prepared by the author and published in June, 1912, ascribed the changed condition of the motor lubricant to the leakage of gasoline vapor during the compression stroke, recondensation of this vapor in the crankcase, absorption by the lubricant, and to a probable slight leakage down the walls of the cylinder of unconsumed heavy portions of the fuel which had mingled with the lubricant, producing a similar effect. This condition has always existed, but has become more pronounced and better understood during the last two years.

[1] Sinclair Ref. Co. Mem.Am.Soc.M.E.

Presented at a meeting of the Chicago Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, January 23, 1920.

The tremendous growth of the automotive industry during the past few years, with the consequent burden placed upon the oil industry of producing the vast amount of fuel required, has brought about an unbalanced condition. Because of the enormous increase in consumption of gasoline—from 15,000,000 bbl. in 1910 to approximately 95,000,000 bbl. in 1919—the petroleum industry has been able to meet demands only by the manufacture of a less volatile fuel.

Navy Department specifications show that during the past few years automotive fuels have been gradually getting heavier, approximately from 360 deg. fahr. end point in 1916 to 428 deg. fahr. end point in 1919. (The end point is the temperature at which the final part of the fuel vaporizes.)

There is ample evidence that this increase in the use of heavy fuels will continue and it follows, therefore, that gas-engine designers must so design their engines as to consume successfully this less volatile product.

LUBRICATION TESTS ON AN AERONAUTIC ENGINE

During the war, before writing specifications for lubricating oils and fuels for aeronautic and other internal-combustion engines, it was necessary to make a complete study of this subject in order that the fuel and lubricants could be so balanced that their combination in the engine would give the necessary lubricating results. These main tests resulted in the specifications for Liberty Aero Oil, and had much to do with specifications for aviation gasolines, including domestic, export and fighting grades. A Hall-Scott aeronautic engine, Type A-7-A, four-cylinder, 100 hp., was used for the special fuel tests of the series. This engine was operated under ideal test conditions, working with the same lubricant but with different fuels. Two of these fuels were made especially for the test and were distilled from the same crude.

The first fuel tested was made after the German specifications for aviation gasoline, and had a gravity of 75.2 deg. B., an initial boiling point of 110 deg. fahr. and a final boiling point of 230 deg. fahr.

The second fuel tested was made after the French specifications and had a gravity of 63.6 deg. B., an initial boiling point of 140 deg. fahr., and a final boiling point of 292 deg. fahr.

The third fuel complied with regular Navy specifications for motor-boat fuel under contract for the year 1917 and had a gravity of 61.3 deg. B., an initial boiling point of 135 deg. fahr. and a final boiling point of 385 deg. fahr. To this fuel a so-called gasoline energizer was added. This produced a fuel which, while it had an initial boiling point of 135 deg. fahr., had an end point of 422 deg. fahr., which in its last distillation range would be equivalent to the present-day commercial gasoline.

The method of conducting the tests was to run the engine continuously for five hours under test conditions, every observation in connection with the operation being recorded. At the end of every hour samples of lubricating oil were drained from the lubrication system of the engine and the same amount of new oil replaced. These samples were examined by a corps of very efficient oil chemists working at the Bureau of Standards, at the oil laboratory in Washington Navy Yard, at two commercial laboratories, and at the Naval Experiment Station at Annapolis.

The effect of the four different classes of fuel upon the same lubricant is clearly registered in the charts in Figs. 1 and 2. The lightest or most volatile fuel shown in test No. 3 caused a lowering of the viscosity of the lubricating oil during the first hour

of 62 sec. (Saybolt universal viscosimeter). The oil, however, recovered its body, and at the end of the fifth hour was 87 sec. above its original viscosity or body.

In test No. 2, Fig. 1, with a slightly heavier fuel, there was a reduction in the body of the oil of 114 sec. during the first hour. The oil, however, recovered after the first hour, and at the end of the fifth hour had a viscosity of 55 sec. above its original body.

Test No. 1, with a semi-commercial fuel, showed a drop in the body of the oil in two hours of 304 sec., with a slight recovery during the balance of the test. There was a total reduction of 136 sec. at the end of five hours from the body of the original oil.

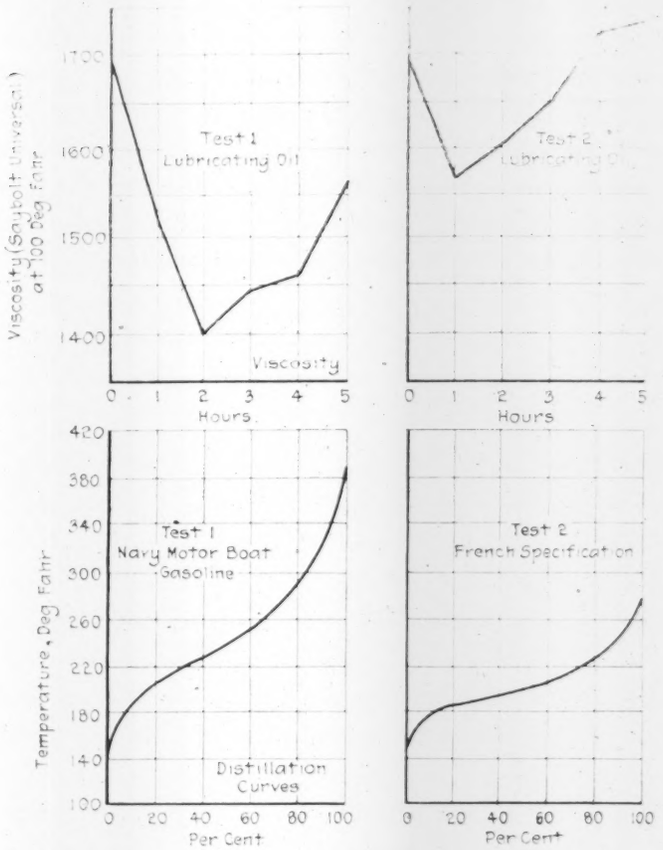


Fig. 1 Curves of Gasoline Distillation and Oil Viscosity Showing Change in Lubricating Oil While Working in Engine

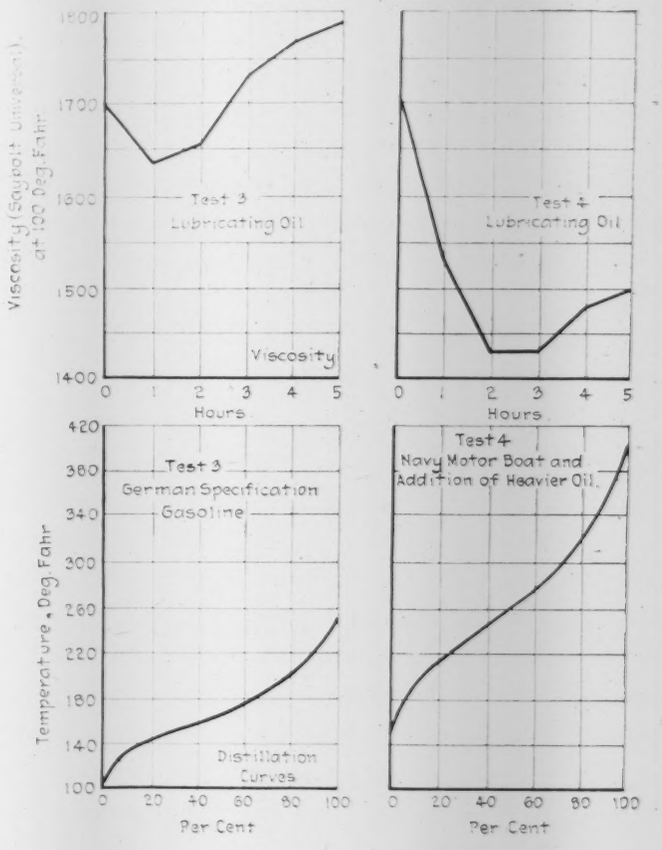


Fig. 2 Curves of Gasoline Distillation and Oil Viscosity Showing Change in Lubricating Oil While Working in Engine

In test No. 4, Fig. 2, with the high-end-point gasoline, there was a drop in two hours of 280 sec. in the body of the lubricant, only a slight recovery and a total drop at the end of five hours of 213 sec. from the original body of the oil.

The sample taken at the end of the five-hour period of each one of these tests was tested in a distillation flask and the amount of heavy end of the gasoline recovered varied from 0.5 per cent to 1.2 per cent as indicated on the chart in Fig. 3. All of the physical characteristics of the oil, such as gravity, flash, fire, viscosity, pour test, acidity, carbon content, showed a considerable change as indicated in Fig. 5.

In Fig. 5 carbon conditions are indicated which are especially interesting as showing the laboratory variations on four samples of the same new oil when taken by the Conradson and the Waters carbon test. Particularly interesting is the sample by weight and residue, test No. A4, where practically commercial gasoline was being used in the engine. This heavier carbon residue or deposit found in the used oil indicates the increased amount of carbon being formed in the engine while using the heavier fuel.

The results of the above tests indicate quite clearly that dilution exists with even the most volatile fuel, but only during certain periods of the operation of the engine and under certain fixed conditions. With the lightest volatile fuel, which would also be the case with the engine operating on producer, natural or furnace gas (some figures on this are given later), the tendency of the lubricating oil would be to build up in body, the same as in any other class of lubrication work where the lubricant does not come in contact with lighter hydrocarbons or lighter volatile products that can be combined with it. These tests also indicate quite clearly that the heavier the end point of the fuel, the greater is the effect of dilution and the more permanent is its character.

It must be borne in mind that in these experiments the aeronautic engine was operated with an exceedingly heavy lubricating oil, such as these engines require, and that carbureter and magneto adjustments were attended to by experts; that the engine was placed in perfect condition for each test and operated continuously without stopping, at high speed, for the entire five hours of the test.

Lubrication Tests on Automobile Engines

The following data were secured from the examination of lubrication conditions of a considerable number of cars and trucks during December, 1919, using commercial gasoline and lubricants as purchased in the Chicago market. In some cases the cars were new as received from the manufacturer, and in other cases old, or old and repaired.

In preparation for the tests, the motors were thoroughly cleaned and the crankcases filled with the oil to be tested. The oils so used covered a range of commercial medium and heavy grades as indicated by Government specifications for motor oils. The cars were allowed to operate in their regular business for periods of ten days, during which time no particular care was given them other than ordinarily given commercial vehicles, but at the end of each two-day period an eight-ounce sample was

drawn from each crankcase and eight ounces of the grade of oil used on that particular motor was put in whenever additional oil was necessary. The samples were examined for dilution by measuring all the product that could be distilled from the sample of oil under 500 deg. fahr. The viscosity (Saybolt) of the sample before removal of the diluent was taken at 100 deg. fahr. The ash test was made in the Conradson carbon apparatus, and after the carbon had been determined a gas flame was used for burning the carbon out of the dish. The ash that remained was then weighed and the percentage taken of the whole sample. This ash was made up of iron, iron oxide and silica. The results of the tests are given in Figs. 6, 7 and 8.

Fig. 6 shows the results on a 3½-ton Diamond "T" truck. This was a new car which had not been run previous to this test. Viscosity at the end of ten days was reduced from 345 to 100 sec. Dilution the tenth day amounted to 19 per cent and ash to 1.62 per cent.

Fig. 7 shows the results on a 5-ton Pierce-Arrow truck which had run 5205 miles. On July 4, 1919, this motor was completely overhauled, new piston rings being fitted. Viscosity dropped from 358 to 90 sec. during the first six days, then recovered to 184 sec. at the end of ten days. Dilution in the case of this truck seemed to be very dependent upon weather conditions; at the end of the six-day period there was 20.6 per cent of dilution, which was reduced to 8 per cent at the end of the ten-day period.

Fig. 8 shows the results on a 3½-ton Packard truck which had run 12,551 miles. Overhauled May 5, 1919; new rings fitted. (NOTE: This truck did not go out of the garage for the first two days. Engine, however, was run during this time for a period that would be equivalent to five miles' operation.) The viscosity held practically constant for the first two days when the truck was not operating in the open. After the second day there was a drop in viscosity to 43 sec. Dilution at the end of the tenth day was 26.5 per cent.

CAUSE OF DILUTION

With the present-day fuel and the present-day automotive engine, all lubricants change considerably in body within a very

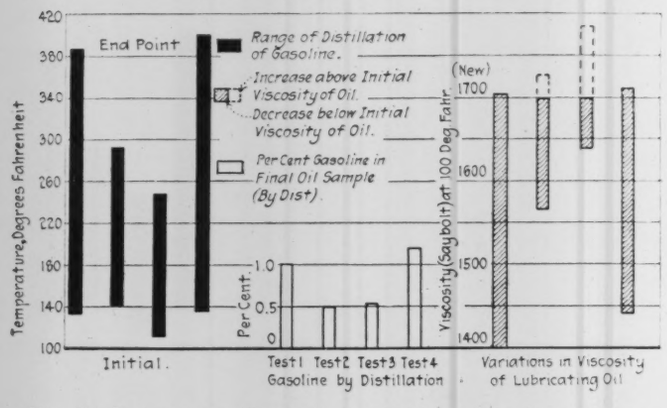

End Point
Range of Distillation of Gasoline.
Increase above Initial Viscosity of Oil.
Decrease below Initial Viscosity of Oil.
Per Cent Gasoline in Final Oil Sample (By Dist)
Temperature, Degrees Fahrenheit
Per Cent.
Viscosity (Saybolt) at 100 Deg. Fahr.
(New)
Initial.
Test1 Test2 Test3 Test4
Gasoline by Distillation
Variations in Viscosity of Lubricating Oil

FIG. 3 RESULTS OF DISTILLATION TEST OF OIL AFTER FIVE-HOUR RUN

short operating period, this new body being the result of dilution and the dilution coming from the heavy end of the fuel.

The amount of dilution is influenced, to a great extent, by the temperature of the surrounding air, the reason being that the colder the engine, the greater the amount of fuel the oil will absorb and hold. Conversely, the hotter the air or lubricating oil in the engine, the less will be the amount of fuel held in dilution, as all the fuel can be distilled off at high temperature.

In order to see if any of the dilution of a motor oil could be caused by decomposition or cracking of the oil by being thrown against hot surfaces, tests were made by the author with a commercial car operated by pure benzol. From 4 to 8 per cent of benzol was distilled from the motor oil after 100-mile runs. After the benzol had been removed the oil possessed all of its original characteristics. Benzol, wherever found, can be determined as such by the chemist. These benzol tests determined satisfactorily that dilution was being caused by the fuel, although an odor of burned oil indicated some degree of decomposition.

The conclusions drawn from the above test with benzol are confirmed by the results of a test on a Nash six-cylinder engine operated with city gas for 10 hr. The original viscosity of the oil at 100 deg. fahr. was 205 sec.; after ten hours' operation the viscosity had increased to 255 sec., the flash and fire points remaining practically the same, showing that there had been no change in the oil caused by cracking and reabsorption of the lighter products, but that the absence of lighter products allowed the oil to become heavier in body.

Dilution is caused mainly by leakage past the piston rings during the compression stroke. There is a secondary leakage

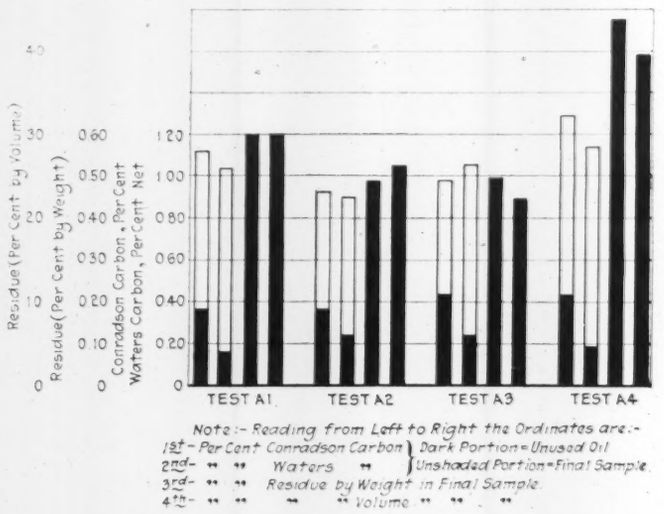

Residue (Per Cent by Volume)
Residue (Per Cent by Weight)
Conradson Carbon, Per Cent
Waters Carbon, Per Cent Net
TEST A1
TEST A2
TEST A3
TEST A4
Note:- Reading from Left to Right the Ordinates are:-
1st- Per Cent Conradson Carbon } Dark Portion = Unused Oil
2nd- " " Waters " } Unshaded Portion = Final Sample.
3rd- " " Residue by Weight in Final Sample.
4th- " " " " Volume " " " "

FIG. 4 RESULTS OF TESTS SHOWING VARIATION OF CARBON CONDITIONS IN FOUR SAMPLES OF NEW OIL

caused during the suction stroke, where there is a partial separation of heavy ends of the fuel from the gas entering the cylinder and absorption by the film of oil on the cylinder walls, causing some drainage on the lower exposed surfaces during the compression stroke. It is doubtful if any drainage or leakage takes place during the exhaust stroke or during the power stroke. If we assume that the losses take place during the admission and compression strokes, we are dealing with one-half of the operating period of the engine, and that will give all the opportunity necessary for the effects that have been noticed to take place.

Leakage of the gasoline or gasoline mixture is influenced by the following mechanical or operation conditions:

1 Piston clearance
2 Richness of mixture
3 Improper ignition
4 Operating temperature of motor affected by weather
5 Body of lubricant or thickness of film on walls of cylinders
6 Condition of cylinder walls
7 Condition of piston rings as affecting their all-around fit in the grooves and against the cylinder walls
8 Intermittent operation
9 Priming and using the choker when engine is cold in starting
10 Choking when overloading
11 Character of fuel
12 Carburetor out of adjustment
13 Vacuum system out of adjustment.

Losses Caused by Dilution

These losses are of four kinds:

1 Loss of fuel
2 Loss of lubricant.
3 Loss of power
4 Wear of all parts.

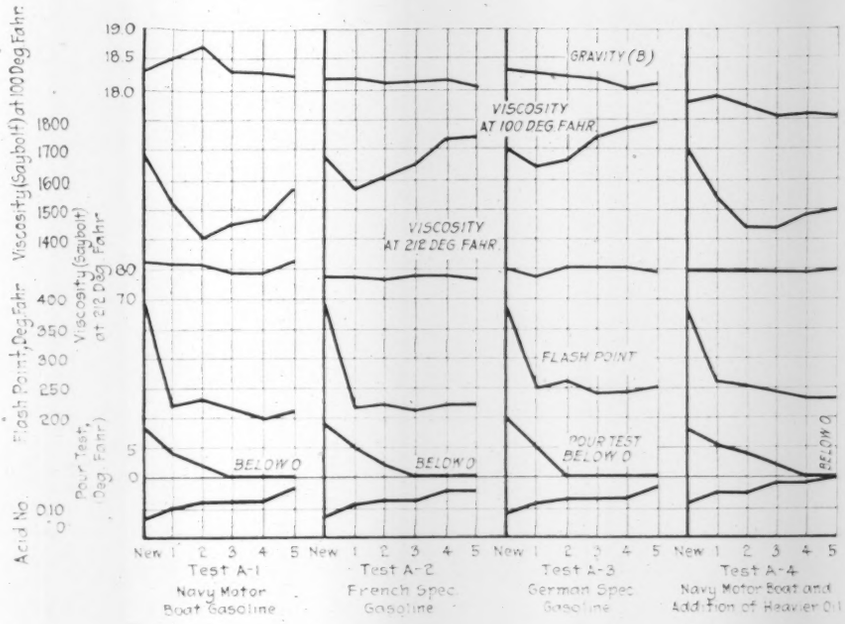

GRAVITY (B)
VISCOSITY AT 100 DEG FAHR
VISCOSITY AT 212 DEG FAHR
FLASH POINT
POUR TEST BELOW 0
BELOW 0
Test A-1 Navy Motor Boat Gasoline
Test A-2 French Spec Gasoline
Test A-3 German Spec Gasoline
Test A-4 Navy Motor Boat and Add tion of Heavier Oil

Fig. 5 Chart of Oil Analyses and Carbon Content; Engine, Hall-Scott, Type A7A, No. 3012, 100 Hp.

Loss of Fuel

This loss is not entirely due to the heavy end of the fuel or to the present heavy character of the fuel, as, irrespective of the nature of fuel, whether light and volatile or heavy, there will be a fuel loss during the compression stroke in a four-cycle engine. In the case of heavy-end fuel this loss is reflected to a magnified extent in the dilution effect upon the lubricating oil. In the case of a very much lighter fuel, say one of 72 deg. B., the loss by the rings during the compression stroke would be just as pronounced in percentage of the amount taken into the cylinder, supposing the sealing effect of the lubricant on the piston rings to be always the same, but the effect would not be as noticeable, due to the lubricant's inability to absorb and hold the lighter fuel as a diluent at operating temperatures.

The amount of fuel lost in this manner is in no way represented by the amount of dilution found in motor oils, as there is a limited point of saturation of a motor oil dependent upon the condition under which it is operating. The losses which constantly occur are disposed of by the engine in some other way than by being entirely absorbed by the lubricant.

The loss of fuel by leakage means that all the fuel placed in the cylinder is not converted into power.

Loss of and Through the Lubricant

The first effect of dilution is upon the viscosity or body of the lubricating oil, reducing this body to a point where it cannot be considered to be an efficient lubricant for a motor. This causes three conditions, which can be stated as:

1 Loss of lubricant
2 Loss of power
3 Wear of the machine

The first effect is the wastefulness of the lubricant, as the entire loss of lubricating oil in an internal-combustion engine is caused by the lubricant creeping up the cylinder walls, mainly during the first cycle or admission stroke, and being later consumed in the combustion chamber. The lighter the oil is in body, the greater will be this loss. Further, there is another loss that is due to the present condition of dilution and the attempts made to offset it, and that is by the removal of lubricating oil from the engine at periods of from 300 to 800 miles, instead of the former periods of double this mileage, this mixture being thrown away.

Loss of Power

The basic rule in lubrication is illustrated best by considering the power necessary to operate a machine composed of a number of bearings. If the machine is lubricated perfectly with oil of the proper viscosity, the power will be at a minimum and speed at a maximum, and there should be practically no wear on the bearings. If, however, an oil of double or treble the viscosity is used as a lubricant, the power necessary to move the machine at the same speed will have to be materially increased, due entirely to the fluid friction of the lubricant itself. Under this condition there will be practically no wear, as the surfaces will be kept well apart. Attempting to lubricate the same machine with an oil that is entirely too light or thin for the work will also require the development of practically as much, or even more, power than in the case of the extra heavy oil, the resistance being due to metallic or solid friction, one of the results of which is, of course, abrasion with constant changing of the surfaces.

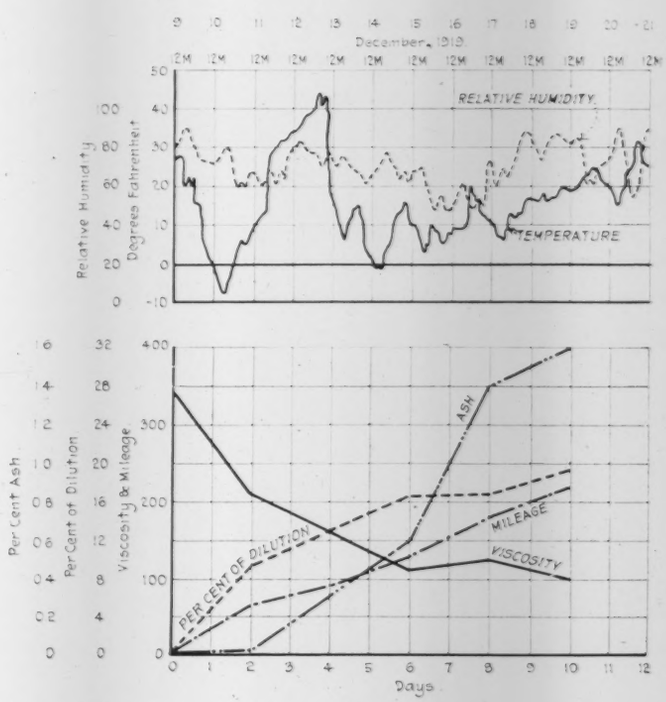


Fig. 6 Viscosity and Dilution Tests of Oil, 3½-Ton Diamond "T" Truck

The general rule as applicable to automotive engines when considering the dilution problem is well illustrated by a test on a tractor engine using kerosene for fuel where the output at the start of the test was 28 b.hp., gradually dropping to 24.5 b.hp. in eight hours, indicating a considerable increase in the frictional

horsepower. The viscosity (Saybolt) of the oil at 100 deg. fahr. changed from 300 sec. at the start to 75 sec. at the finish of the test, at which time there was 36 per cent of dilution in the oil. Temperature of oil in crankcase increased from 98 deg. fahr. at start to 135 deg. fahr. at end of run.

A lubricant actually working in a motor should have a body at least equal to that possessed by a new heavy spindle oil (130 sec. viscosity at 100 deg. fahr.) and an oil of such light body must be used in a forced-feed system where the pressure and constant flow of the oil will make up for its lack of thickness of lubricating film.

As a matter of fact, under present conditions of operation most motor oils when in an engine, in the winter especially, are much lighter than a lubrication engineer would ever think of applying to the lightest piece of machinery he would be called upon to lubricate, which is a light spindle in a textile mill. A description of these spindles will permit comparisons to be made. They rotate at about 10,000 r.p.m., and the side pull or pressure averages 2 lb. The pressure on the bearing side will not be above 10 lb. per sq. in. The high rotation speed of the spindle tends to keep it away from the bearing surface and keep it in the center of the bolster. About one ounce of oil is placed in the base of the spindle, and this amount is added to every 15 to 45 days. It has been proved by the most careful experiments that oil that has a viscosity (Saybolt) of less than 60 sec. at 100 deg. fahr. will allow these spindles to wear perceptibly in a month's time. The oil remaining in the spindle base will become black and contain a very considerable proportion of iron and iron oxide. Further, the same spindles when lubricated with oil of from 70 to 80 sec. viscosity do not wear, due to the fact that the oil is of sufficient body to keep the surfaces apart.

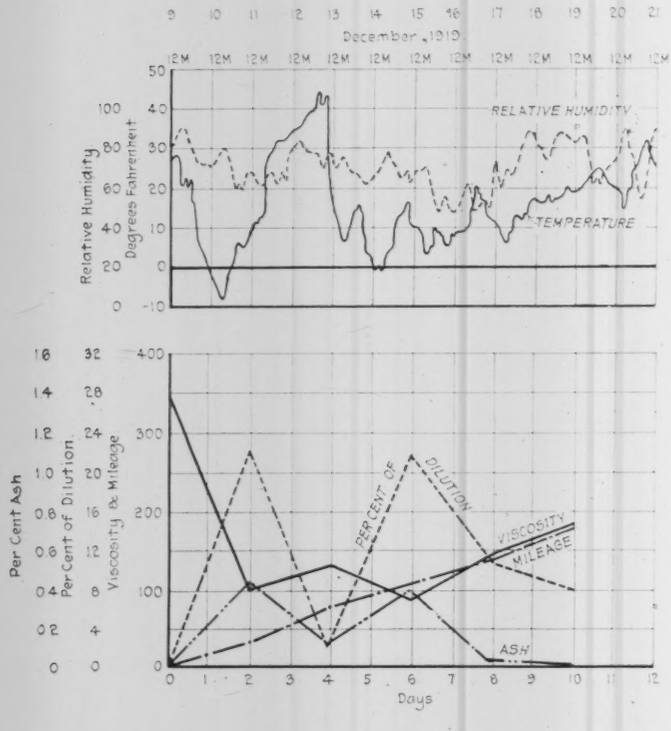


FIG. 7 VISCOSITY AND DILUTION TEST OF OIL, 5-TON PIERCE-ARROW TRUCK

Therefore, the result of the lubrication of an automotive engine with a mixture of lubricating oil and heavy ends of the gasoline having a viscosity below that required for a textile spindle can only result in excessive wear, and this is shown by the ash remaining from the complete distillation of the sample of mixture taken from the motor.

WEAR OF MACHINE

The effect of poor lubrication is indicated to some extent by the readings of ash. These readings were taken on each sample and represent the total amount of ash in that particular sample. The ash is made up of oxide of iron, other metal, and of silica,

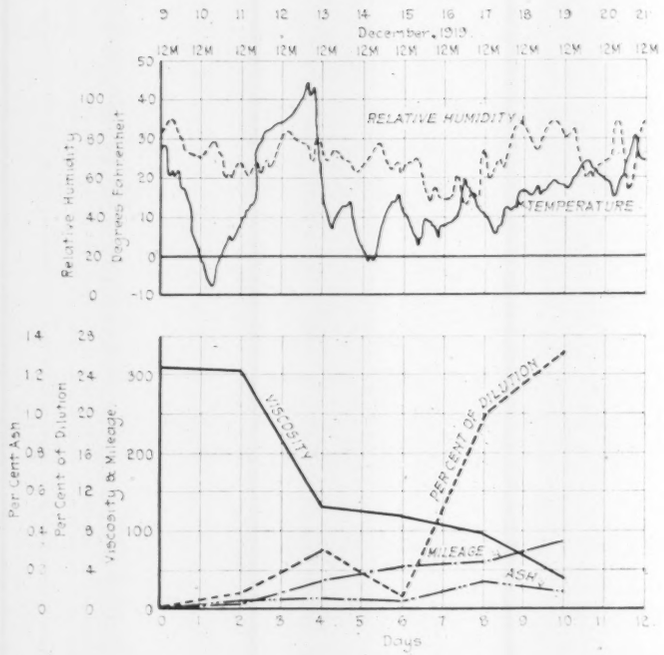


FIG. 8 VISCOSITY AND DILUTION TESTS OF OIL, 3½-TON PACKARD TRUCK

the iron and other metal being from natural or unnatural wear of the engine, the oxide of iron coming from the water that has been in contact with the metal, and the silica coming from road dust, though at the time of the year this particular test was made the streets were well covered with snow and but little road dust could be expected to enter the engine through the carbureter or breather holes.

The wear of the machine is reflected in repair bills, in the necessity for reboring cylinders and refitting rings when an engine becomes noisy and when compression is lost.

All of these matters are so well known as not to need explanation. They are largely the result of wear caused by the present unbalanced condition of fuel, lubricant and engine.

CONCLUSION AND RECOMMENDATIONS

As engineers we are now faced with a very definite problem. It is necessary to reconsider the entire problem of the internal-combustion engine on the basis of present-day fuel and its effect upon the lubricant. There is but little more that the oil industry can do in regard to the fuel situation. Considerable can be done in regard to the application of motor oil; that is, the selection of motor oil for these engines upon some other basis than has generally been prevalent in the past whereby a motor of any one manufacturer was supposed to be properly suited by a certain grade of lubricant for its entire life irrespective of its physical condition. Modern lubrication engineering can, to a very considerable extent, rectify some of the damage done by this old system of selecting lubricants, basing the selection upon more scientific or practical grounds, taking into consideration all of the factors which surround the problem.

The entire problem of lubricant, fuel and engine conservation can only be solved by the automotive engineer or designing mechanical engineer providing means and methods whereby the fuel

(*Continued on page* 193)

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

SUBJECTS OF THIS MONTH'S ABSTRACTS

ALOXITE AA, NEW ABRASIVE
ABRASIVE MATERIALS AND SIZE OF GRAIN
DRYING, THEORY OF
DRYING, MOST ECONOMICAL TEMPERATURES
AIR, MOIST, GRAPHIC DETERMINATION OF WEIGHT
COPPER, INTERCRYSTALLINE BRITTLENESS
FATIGUE OF METALS UNDER REPEATED STRESSES
MOLYBDENUM STEEL
FERROALLOYS OF RARE METALS
DIE CASTING
AIRCRAFT FUEL TESTS
NEPTUNE DIESEL ENGINE
GEOMETRIC PROGRESSION OF SPEEDS IN MACHINE TOOLS
MECHANICAL STOKERS ABOARD SHIP
PRODUCER GAS FOR MOTOR VEHICLES
SMITH PORTABLE GAS PRODUCERS
DUPLEX AUTOMOBILE MOTOR
STEAM POWER PLANT STATISTICS
ROCKET ACTION IN THEORY
GODDARD ROCKET
ATMOSPHERE, INVESTIGATION AT EXTREMELY HIGH ALTITUDES
NEW BRITISH PATENT ACT

AERONAUTICS (See Internal-Combustion Engines)

ABRASIVES

NEW ALUMINOUS ABRASIVE. Otis Hutchins. Description of an abrasive material known as Aloxite AA, developed by the Carborundum Company. The main application of the new abrasive is expected to be for the grinding of reamers, cutters and small tools and also for certain kinds of cylindrical grinding.

The chief structural characteristic of the new abrasive is the large size of the alumina crystals found therein.

The importance of this factor lies in the following: When the alumina crystals in the abrasive material are small a rupture of the grain may mean a tearing away of a few small crystals without fracture. When, however, the crystals are large and a rupture occurs in an abrasive grain it means that the crystal of alumina has been fractured and that new sharp cutting points have been produced. In this way, during the process of grinding, there is a breaking down of the abrasive grains in the wheel and the character of the new cutting edges is such as to facilitate an easy removal of the ground material. (*American Machinist*, vol. 52, no. 3, Jan. 15, 1920, pp. 113-114, 3 figs., *d*)

DRYING

Drying Theory, Most Economical Temperatures, Graphic Determination of Weight of Moist Air

CONTRIBUTION TO THE THEORY OF DRYING, E. Hoehn. Discussion of the most economical temperature and most economical degree of saturation for the air at the outlet from the drying chambers; discussion of influence of air pressure; and graphical methods for the solution of problems in connection with processes of drying.

Most Economical Temperatures. The fact that the highest possible temperature of air is the most economical in drying is well known. This is due to the fact that the ability of air to hold moisture rises very much more rapidly than does its temperature.

A good deal less information is available, however, as to the temperature at which the air should leave the drying chamber. (Such air is referred to in what follows as "exhaust air.") As regards this latter, the impression seems to prevail that it is of advantage to have such air leave the drying chamber at the lowest possible temperature and the highest possible degree of saturation. The assumption as regards the necessity of employing a high degree of saturation in order to insure the economic operation of the drying process is correct, but the assumption as to the necessity of keeping the air at a low temperature rests on an erroneous conception of the character of the process. In order to clear up this matter, the author investigates how many grams of water each heat unit (kg.-calorie) contained in the air (considered as a mixture of air and water vapor) can carry away.

The weight of 1 cu. m. of moist air is composed of ϕG_d kg. of water and $0.465 \frac{p - \phi p_d}{273 + t}$ kg. of dry air. In this formula ϕ is the degree of saturation in per cent; G_d the weight in kg. of 1 cu. m. of saturated steam at the temperature t; p the barometric pressure of the air-water vapor mixture in mm. of mercury; p_d the steam pressure at the temperature t (really the partial pressure of the steam content in the mixture) in mm. of mercury. Further, p_1 is the partial pressure of the air equal to $p - \phi p_d$ in mm. of mercury.

In this formula G_d and p_d for a given temperature can be found in steam tables; the degree of saturation ϕ can be measured by means of a hygrometer, or more precisely by a psychrometer. The heat content of 1 cu. m. of mixture at temperature t (or 1 cu. m. of the mixture of the weight given above) is equal to

$$J = \phi G_d i + 0.465 \frac{p - \phi p_d}{273 + t} 0.24t$$

where i is the heat content of 1 kg. of steam at temperature t; the coefficient 0.24 is the specific heat c_p of 1 kg. of air at constant pressure (all values in metric units).

It is clear from the above that the weight of water vapor corresponding to one heat-unit (kg.-calorie) content as part of the total heat content in 1 cu. m. of moist air is $\phi G_d / J$. It is desirable to plot this fraction as a function of temperature t in order to see what would be its maximum and minimum values. To do this the author, instead of resorting to the complicated analytical treatment of the problem, simply computes the values of the numerator and denominator of the fraction and plots the quotients as coördinates with the temperatures as abscissæ. This is all the easier as both the parts of the fraction can be read off from existing tables, and as it does not matter whether the values are taken for the case of 1 cu. m. of moist air or for such a volume that the dry air contained therein would weigh 1 kg. (The tables are computed for the latter case.) If this computation be carried out for the barometric pressure of 720 mm. of mercury the curves of Fig. 1 are obtained.

This gives the desired picture showing the ability of the air to take up moisture as measured by heat content of the air. It appears that the curves come down at about 15 deg. cent. and then rise again, the greatest rise lying between 30 and 70 deg. Hence, the least favorable temperatures for drying purposes are located in the region of 15 deg. where the curves are at their lowermost points. In this region 1 kg.-calorie of heat contained in the air will enable the latter to carry off the least amount of water.

Attention is called also to the fact that Fig. 1 justifies the assumption that it is just at the average temperatures prevailing

in the summer that the greatest consumption of heat is required by nature for the purpose of humidification of the air. From this point on, that is, from about 20 deg. cent., the absorption of moisture in drying becomes more economical the higher the temperature of the exhaust air is carried, assuming, of course, equal degrees of saturation. In the case of perfectly dried air ($\phi = 0$ per cent) the ordinate is zero and the curve reaches the axis of abscissæ. The highest location of the curves is at about 1.56 to 1.54 grams per large calorie. Each curve ends at its highest point, which latter corresponds to a definite state of mixture which is determined in the following manner. When in the weight

$$G = \phi G_d + 0.465 \frac{p - \phi p_d}{273 + t}$$

a partial steam pressure p_d reaches the level of the total pressure p, that is, when $\phi p_d = p$, and hence the partial pressure of the air $p_1 = p - \phi p_d = 0$, the second member of the right-hand side disappears; in other words, air disappears from the mixture and

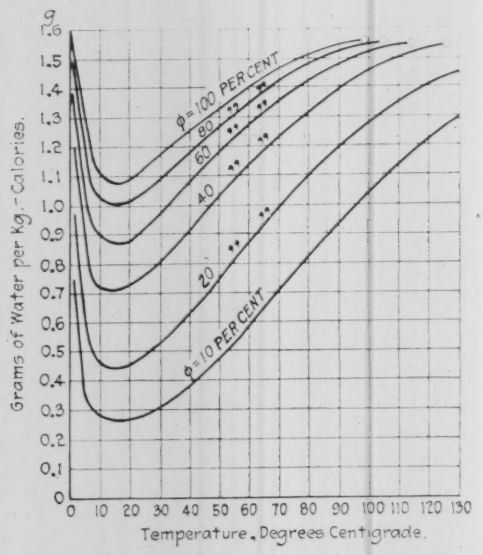


FIG. 1 CURVES OF MOISTURE CONTENT IN GRAMS AT VARIOUS DEGREES OF SATURATION AS FUNCTION OF TEMPERATURE t WHICH CAN BE CARRIED OVER BY 1 CU.M. OF MOIST AIR FOR EACH LARGE CALORIE OF THE HEAT CONTENT OF THE AIR

only steam is present. If, at the same time, ϕ becomes equal to 100 per cent, we are dealing with a state in which the dewpoint is reached and this can occur only where the steam pressure is equal to the total pressure. This point may be called the limit dewpoint. When $\phi < 1$ we can find such a steam pressure p_d on the basis of the temperature t, so that $\phi p_d = p$. Thus, with $\phi = 0.5$ the steam pressure $= p_d$ is 1520 mm. of mercury, at which at the barometric pressure of 760 mm. the steam drives the air entirely out of the mixture. This can happen at $t = 120.6$ deg. cent. It is obvious that the consumption of heat in the heat carrier is at its minimum when the heat carrier consists entirely of steam and no air is present. In Fig. 1 the curve $\phi = 100$ per cent at its interpolated continuation constitutes the upper limit of the region within which drying is at all possible. Fig. 1 gives also valuable information as to what degree of saturation is most economical. When very high degrees of saturation, such as 80 or 90 per cent, have been reached a further rise of saturation does not appear to improve matters very much. On the other hand, in the lower regions of saturation, such as 50 or 60 per cent, the amount of water carried away increases more rapidly with the heat consumption. On the whole, the curves of Fig. 1 would tend to indicate that the economy of the process is the same whether we operated with moist air of, say, 40 per cent saturation at 78 deg., or 60 per cent saturation at 63 deg., or 80 per cent saturation at 54 deg., or perfect saturation at 46 deg.; in all of these cases we have to expend 1 kg.-calorie in order to carry off 1.3 grams of water. The conditions most easily attainable mechanically and still satisfactory from an economic point of view would lie, as far as temperature is concerned, between 60 to 80 deg. cent. and 60 to 80 per cent of saturation, in which case we expend roughly 1 kg.-calorie of heat to take care of 1.4 grams of water, which means an expenditure of 0.7 kg.-calorie of heat for one gram of water, or 700 kg.-calories of heat for 1 kg. of water.

This is very nearly the same as the heat necessary to evaporate 1 kg. of water at atmospheric pressure, which is 640 kg.-calories. Under this condition the efficiency of drying is close to 90 per cent.

At 100 deg. cent. and $\phi = 100$ per cent, that is, when the air is entirely driven out of the mixture by the steam and the limit dewpoint is reached, the end point of the curve shows a consumption of 1 kg.-calorie of heat to take care of 1.56 grams of water. The correctness of this figure can be proved in the following manner. Since 1000 kg.-calories of heat can take care of 1.56 kg. of water, to evaporate 1 kg. of water we have to consume 640 kg.-calories of heat, which is the value found in steam tables. A 100 per cent saturation at 100 deg. cent. is, however, unattainable in practice, since the drying process would have to operate at an efficiency of 100 per cent to make it possible, and such efficiency is not attainable.

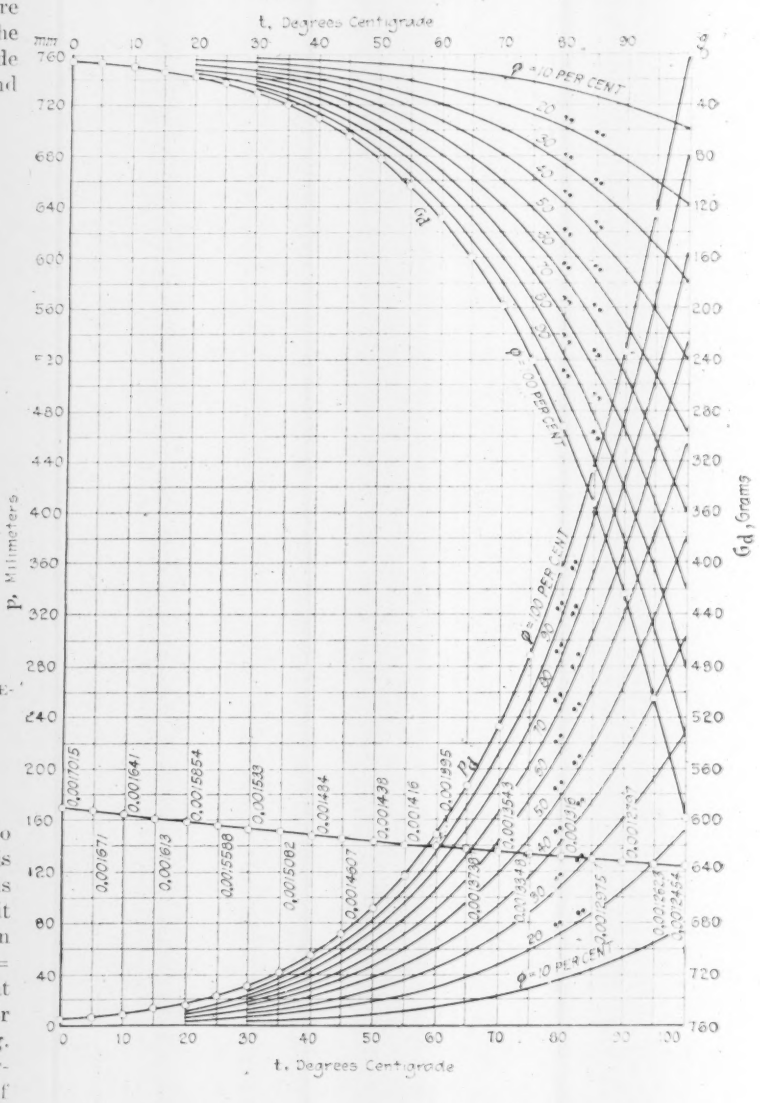


FIG. 2 CHART FOR COMPUTING THE WEIGHT OF MOIST AIR WHEN ITS TEMPERATURE AND DEGREE OF SATURATION ARE KNOWN

Graphical Determination of Weight of Moist Air. As indicated

above, the weight of 1 cu. m. of moist air in kg. may be calculated from

$$K_t = \frac{0.465}{273 + t}$$

$$G = \phi G_d + \frac{0.465}{273 + t}(p - \phi p_d)$$

We can represent these equations graphically by taking the first factor from the steam table and multiplying it by the value of the degree of saturation. This is done in Fig. 2 where the weight of steam ϕG_d is plotted as ordinates from the upper axis of abscissæ downward, while the temperatures are plotted as abscissæ.

As regards the second factor, both parts of it are reproduced graphically; $\frac{0.465}{273 + t} = K_t$ is at zero deg. fahr. = 0.0017015 and at 100 deg., 0.0012454. Any scale may be selected to plot this curve and it will be found in Fig. 2 as a practically straight line on the bottom.

At partial air pressure $p_1 = p - \phi p_d$, the maximum barometric pressure $p = 760$ mm. is selected as the length of the highest ordinate and measured from the bottom upward; p_d, which is the steam pressure at complete saturation or a function of the dewpoint curve, is transferred into the diagram from the steam tables and measured from the bottom upward; ϕp_d, which is the partial pressure of steam dependent on the degree of saturation, is to be found on one of the curves located below the dewpoint curve ($\phi = 100$ per cent).

Hence, the partial air pressure $p - \phi p_d$ is represented by the section of the ordinate located between the curve of total pressure p (for example, barometric pressure of 720 mm.) and the corresponding curve ϕp_d, but the value of $p - \phi p_d$ is multiplied by the coefficient K_t corresponding to the given temperature and the product, which is $K_t(p - \phi p_d)$, is to be added to the length of the ordinate ϕG_d located on the same ordinate t and measured from top downward.

The curves in Fig. 2 may be therefore used for a rapid computation of the weight of moist air for all cases and for barometric pressures up to 760 mm. pressure in C. G. S. units.

Other parts of the article may be abstracted at a later date. (*Beitrag zur Theorie des Trockens und Dörrens*, E. Höhn, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 63, no. 35, August 30, 1919, pp. 821-826, 5 figs., *tp*)

ENGINEERING MATERIALS (See also Abrasives)

A PECULIAR TYPE OF INTERCRYSTALLINE BRITTLENESS OF COPPER, Henry S. Rawdon and S. C. Langdon. When copper is heated in a molten bath of sodium chloride for the purpose of cleaning and softening, it has been noticed that the copper becomes embrittled. Under these conditions the copper is more or less in contact with iron or steel, either from a stirring rod, forceps for handling the piece or the pot used to contain the salt, and a "galvanic couple" with the copper serving as cathode would be formed.

Experiments were made with small rods of copper and mild steel which were made either anode or cathode in a bath of molten salt and with an e.m.f. of approximately six volts. The brittleness of the copper rods was compared with untreated material by bending the specimens back and forth with one end firmly clamped.

The copper rod which was an anode was as tough and soft as the original and required practically the same number of bends to cause it to fracture. The cathode copper was found to be very brittle.

Microscopic examination showed the anode copper to be perceptibly smoother on the surface than the original material; the structure was that of annealed copper. In the cathode copper rod the crystalline boundaries on the surface are well defined, and the intercrystalline boundaries for an appreciable depth within the metal are made wider.

The probable explanation of embrittlement of the copper when it is made the cathode is that an appreciable amount of metallic sodium is formed by the electrolysis which immediately alloys with the copper, the attack being selective toward the grain boundaries rather than forming an alloy layer of uniform thickness upon the outside. (Abstract of *Technologic Paper of the Bureau of Standards*, no. 158, *e*)

Endurance Diagram as Criterion of Fatigue of Metals

FATIGUE OF METALS UNDER REPEATED STRESS, Herbert F. Moore. Discussion of fatigue failure of metals; criticism of some methods of determining it and discussion of a proposed standard method of the determination of fatigue resistance, namely, by means of an endurance diagram.

The author does not believe that elastic-limit figures help in any reliable way to judge as to the permissible fatigue stresses. He likewise does not attach much importance in this connection to a test consisting in subjecting samples of materials to a comparatively small number of violent bends or twists and measuring the amount of the bending or twisting; though he does believe that such a test might be of value in testing material for crankshafts, in spite of the fact that it does not constitute a reliable index of the ability of a material to withstand long-time fatigue under working stress. In the author's opinion the best criterion for fatigue resistance is found in the *endurance diagram*, in which fiber stresses are plotted as ordinates and numbers of repetitions to produce failure are plotted as abscissæ. Fig. 3 shows several such diagrams. This kind of diagram can be advantageously plotted on logarithmic cross-section paper, in which case the plotted points usually fall fairly closely along straight lines, at least up to one million repetitions of stress. The ordinates of such a stress endurance diagram show the fatigue strength for any given number of repetitions and the slope of the diagram gives an index of the relative fatigue-resisting strength for high stresses and for low stresses. Some uncertainty exists for the regions above four and five millions of repetitions, but this is true for all repeated-stress tests.

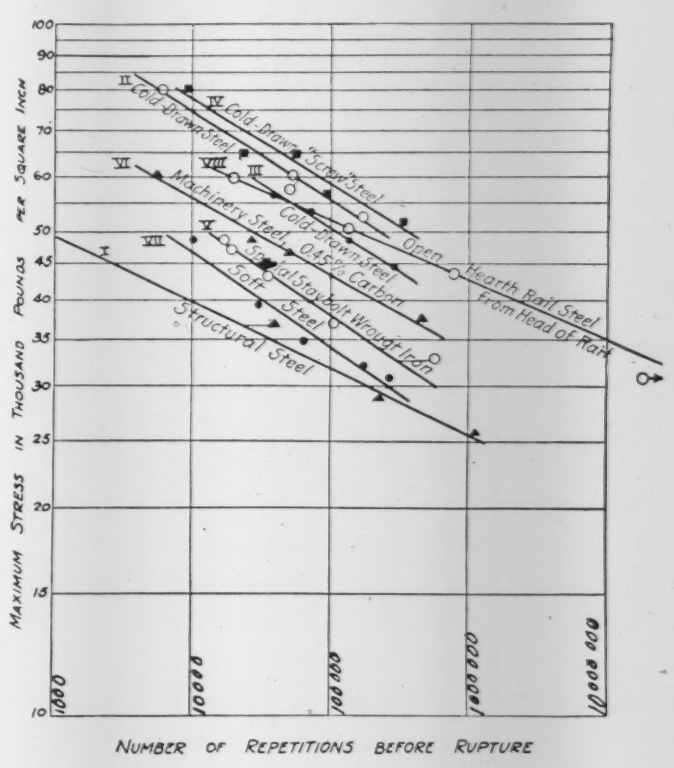


FIG. 3 ENDURANCE DIAGRAM FOR VARIOUS METALS TESTED UNDER REPEATED STRESS

A fatigue failure of a machine part may start at some surface

irregularity, especially at a sharp inward-pointing corner, a groove or even a deep scratch. Polishing the surface of test specimens has been found to greatly increase their resistance to fatigue, especially under low stress and long-time tests. Another method of increasing resistance to fatigue stresses is by using generous fillets at shoulders. (*Journal of the Western Society of Engineers*, vol. 24, no. 6, June 1919, pp. 331-336 (for the paper), and pp. 336-340 (discussion), 4 figs. in the paper, *ep*)

Molybdenum in Chrome and Chrome-Nickel Steels

MOLYBDENUM IN COMMERCIAL ALLOY STEEL. Data of an investigation of these steels published by a commercial organization. Only the most important conclusions are reported here.

The addition of molybdenum to chrome steel increases the elastic limit to a more marked degree than would the further addition of chromium. But the brittleness is not only not increased, but actually decreased with the addition of molybdenum, the greater toughness being shown by the higher elongation and reduction of area.

In chrome-nickel steel molybdenum is claimed to increase the toughness of the material to a considerable extent.

Data are given on the properties of a chrome-vanadium steel, with additions of molybdenum up to the one present.

TABLE 1

Carbon 0.25–0.32	Manganese 0.71–0.76	Chromium 0.45–1.04	Silicon 0.11–0.22	Molybdenum 0.32–0.46
			(On finished crankshaft)	
Elastic Limit 131,700	Tensile Strength 149,900	Elongation Per Cent 17.7	Red. of Area Per Cent 61.8	Brinell Hardness 304

For spring steel, the type in Table 2 is said to have been found quite serviceable. This steel is in use on the Fifth Avenue buses of New York.

TABLE 2

Molybdenum—0.25 to 0.40 per cent

Carbon 0.40–0.50	Manganese 0.60–0.80	Silicon 0.10–0.20	Chromium 0.80–1.10
Elastic Limit	Tensile Strength	Elongation Per Cent	Red. of Area Per Cent
180,000 to 210,000	200,000 to 230,000	12 to 15	37 to 45

* Down to 0.35 for forgings. Up to 0.60 for rivet sets, etc.

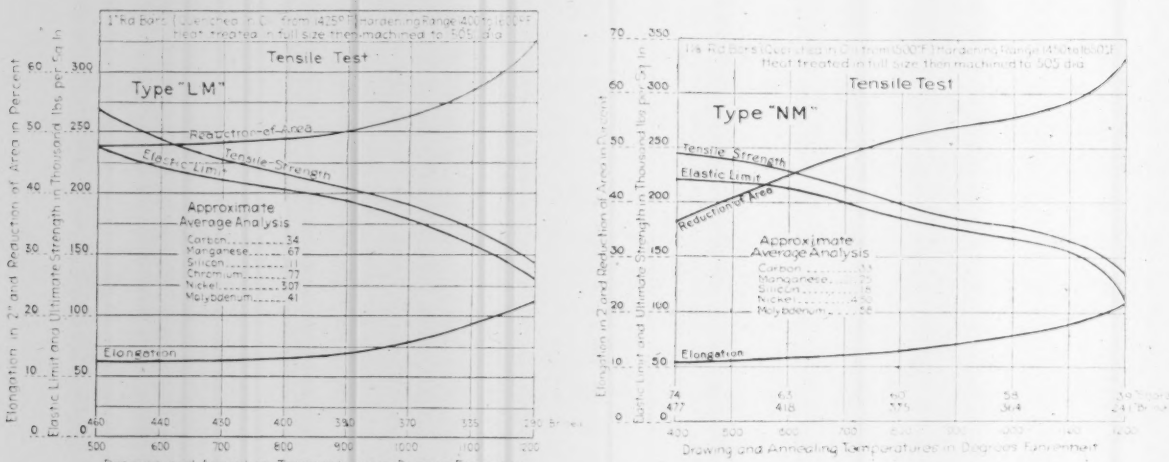


FIG. 4 THE RELATIVE PROPERTIES OF NICKEL-CHROME-MOLYBDENUM STEEL (LEFT) AND A NICKEL-MOLYBDENUM STEEL AT VARIOUS TEMPERATURES AND HEAT-TREATMENT CONDITIONS

As regards molybdenum in nickel steel, it is claimed that its addition increases the elastic limit, toughness and ductility, the effect being particularly pronounced when the steel is drawn at higher temperatures.

Molybdenum steels as a class permit a wide temperature range in which they can be heat-treated without detriment to their physical properties.

In the original article, figures selected from tests on commercial tonnages are given to illustrate this point, and it is claimed that, despite the extremely wide range in quenching temperatures, the variation in physical properties is slight. Tests made within a quenching range of as much as 300 deg. fahr. have shown the practical uniformity of results. In all steels so tested the content of molybdenum varied from 0.25 to 0.40 per cent.

It is also stated that molybdenum steels are less liable to warp in the course of manufacture.

Of the three grades of chrome-molybdenum steels, the one of medium-carbon content is probably the most important commercially, as it is used for parts in automotive equipment such as crankshafts, connecting rods, front axles, etc. Tests on approximately 4000 finished crankshafts forged from this type of steel showed the average properties of the metal to be as given in Table 1.

Chrome-nickel-molybdenum steel was used on Liberty-motor crankshafts, and Table 3 gives the results of tests made by a commercial company.

TABLE 3

C. 0.305	Mn. 0.69	Si. 0.52	Cr. 0.98	Ni. 3.05	Mo. 0.54
0.236	0.50	0.08	0.74	2.85	0.32
Elastic Limit 130,000	Ultimate Strength 142,000	Elongation Per Cent 20.5	Red. of Area Per Cent 65.0	Izod 67	Brinell 303

The crankshafts were treated as follows: Forged and then twisted through the required angle; shaft is then annealed at 1600-1650 deg. fahr. to relieve strains. Time at heat is about 1½ hr. Cooled in air. Heated in an electric furnace to 1475 deg. fahr., held ½ hr. and quenched in water. Drawn at 1150 for 2 hr. Cooled in air and straightened before the temperature has reached 800 deg. fahr.

Fig. 4 is of interest, as it gives the relative properties of a nickel-chrome-molybdenum steel (left) and a nickel-molybdenum steel (right) at various temperatures and heat-treatment conditions.

Molybdenum may be introduced into steel either as a ferroalloy or in the form of calcium molybdate. One of the large deposits of molybdenum in the form of molybdenum sulphide is located in this country at Climax, Colo., and is owned by the Climax Molybdenum Company. ("Molybdenum Commercial Steels," published by the Climax Molybdenum Co., abstracted through *Iron Age*, vol. 105, no. 6, Feb. 5, 1920, pp. 407-409, 3 figs., *ep*)

DEVELOPMENTS IN SOME OF THE RARER FERROALLOYS. The following extracts regarding some of the recent developments in the more uncommon ferroalloys are taken from British sources:

Ferromolybdenum. During the last couple of years the Canadian Imperial Munitions Board have produced 100,000 lb. of 70 per cent ferromolybdenum by the direct smelting of molybdenite concentrate at the works of the Tivani Electric Steel Co., Belleville, Ont. Vertical cylindrical furnaces of the single-phase type are employed, requiring 3000 to 4500 amperes at 50 volts per furnace. Each consists of an iron shell, lined with red brick, firebrick, silica brick, and carbon in succession, and resting on a concrete foundation. The lower electrode consists of a water-cooled bronze or copper block, from which iron rods project upward into the furnace bottom, and the upper electrode of a graphite or carbon rod. For the production of 70 per cent alloy from concentrate containing MoS_2 75 and Fe 9 per cent, the charge consists of concentrate 100, lime 120, coke 10, and scrap steel 5 lb. Each furnace is tapped every 4 hr., the output being 1050 lb. of alloy per 24 hr. During the two years in which the plant was operated for the production of ferromolybdenum containing Mo 70, S 0.4, and C 4 per cent, the average composition of the product was Mo 70.43, S 0.38, and C 3.56 per cent.

Ferrouranium. Up to the present time the use of uranium in steel manufacture is not very fully developed or understood. The abundance of sodium uranate ($Na_2U_2O_7$), a by-product from the extraction of radium and vanadium from carnotite, provides the material from which the oxides are produced. The alloy is made by reducing the oxides with carbon according to the following equations, and then mixing with iron:

$$UO_2 + 2C = U + 2CO \qquad 3UO_3 + 5C = U + U_2C_3 + 2CO$$
$$U_3O_8 + 8C = 3U + 8CO \qquad U_3O_8 + 11C = U + U_2C_3 + 8CO.$$

The alloy usually contains from 25 to 35 per cent of uranium and under the microscope the uranium seems to be present, as the double carbide of iron and uranium, $Fe_3C.U_2C_3$, as a eutectic mixture of iron and carbon. It has been claimed that 0.5 per cent of uranium will replace several per cent of tungsten in tool steel, and the alloy is being used in making ternary uranium and quaternary uranium-tungsten steels.

Ferrozirconium and Ferroboron. Ferrozirconium is one of the latest of the ferroalloys to come into use. It is made by the reduction of zirconia, with aluminum, by the thermit process, to the element and then alloyed with iron. In Great Britain a 20 per cent ferrozirconium has been used to some extent in the place of ferrotitanium.

Ferroboron can be made by the reduction of a mixture of boron oxide and iron oxide with carbon in the electric furnace. Not much is known about this alloy, but experiments in France have shown that a very strong and tough steel can be made by using from 0.5 per cent to 2 per cent of boron.

Ferroaluminum. Ferroaluminum has been largely replaced in recent years by the metal aluminum, but it is suggested that a revival of its use would be desirable. It can be made by mixing scrap iron or iron ore with bauxite and reducing material. It formerly contained from 10 per cent to 20 per cent aluminum, but recent success in the production of ferroalloys indicates that a 50 per cent alloy could be produced. Aluminum is seven times as powerful as silicon and 28 times as strong as manganese in action upon the oxygen dissolved in steel, so that from one ounce to one pound of aluminum is sufficient to deoxidize a ton of steel. (*The Iron Age*, vol. 105, no. 7, February 12, 1920, p. 484, *g*)

FOUNDRY

DIE-CASTING PARTS AND METALS. Brief statistical data of the American die-casting industry, the description of die-casting machines, metals used and methods.

The article brings out such recent developments in the die-casting industry as casting of parts in metals fusible at high temperatures, such as various bronzes and brasses, in particular, aluminum bronze.

It would appear that for low-fusible alloys, soft low-carbon steel makes a very good material for dies, both in respect to its ability to stand up to the work and to the comparatively low cost of production of dies. For use with alloys having high melting points, however, low-carbon steel is entirely unsuitable and materials of the order of tool steels have to be used, as they retain their hardness at temperatures of the metal when injected into the die. However, they make the production of dies both more difficult and more costly.

In addition to this threads cannot be cast on parts made from such materials as aluminum bronze, as can be done with white metal. This inability to cast threads is attributed to the failure of the small pieces of metal used for thread cores to withstand the high temperatures present for any length of time. (Serial article, *Raw Material*, vol. 2, no. 1, Jan. 1920, pp. 468-474, 13 figs., *d*)

FUELS (See Internal-Combustion Engines, Motor-Car Engineering)

GAS PRODUCERS (See Motor-Car Engineering)

INTERNAL-COMBUSTION ENGINES (See also Motor-Car Engineering)

Bureau of Standards Tests of Various Gasolines and Benzol Mixtures

FUELS FOR AIRCRAFT ENGINES. Symposium of three papers discussing the power characteristics of various fuels on the basis of tests made in the altitude laboratory of the Bureau of Standards and associated organizations.

The first paper (by H. C. Dickinson, W. S. James, E. W. Roberts, V. R. Gage and D. R. Harper, 3rd) presents data of tests of nine types of gasolines compared in turn with standard gasoline as a reference fuel.

Two of the fuels were representative American straight-run gasolines closely complying with the specifications for export gasoline. A third followed closely the specifications for fighting gasoline, while two others were slight variations of the fighting gasoline. These were imported from France. Two gasolines represented the average motor-car gasolines as sold by automobile filling stations, one of these being of eastern origin and the other a California gasoline. These fuels were tested quite thoroughly and among the properties the following were determined: Distillation curves, mean volatility, heat of combustion, critical solution temperature, chemical composition and magneto-optic rotatory power.

The reason of this latter test was as follows: In determining the properties of various organic mixtures it has been found that the presence of considerable proportions of compounds of the benzene group has a tendency to increase the rotation of the plane of polarization when a beam of monochromatic light is passed through the substance in a strong magnetic field. The presence of the benzene group has been thought by some to be associated with increased engine power. Thus, it was a conceivable hypothesis that the magnetic rotation might prove a convenient indicator of the power-producing ability of the fuel. This was worth while finding out, especially as this property of the gasolines could be measured very rapidly. Actually, no definite connection between the magneto-optic rotatory power and the engine performance of a gasoline was proved.

The tests on the whole have indicated that when the necessary carburetion changes have been made to suit each fuel, the difference in power-producing qualities of the various gasolines was

quite slight and the extreme difference was of the order of the magnitude of 5 per cent, which, considering the permissible variation in this kind of work, is very little.

The paper by E. W. Roberts discusses the power characteristics of Sumatra and Borneo gasolines. It appears that the sample of Sumatra gasoline tested develops slightly more horsepower than American standard export aviation gasoline, while the sample of Borneo gasoline develops slightly less horsepower. Fractional distillation shows a lower volatility for the sample of Borneo gasoline than for the sample of Sumatra.

The fuel economy with Sumatra gasoline was higher than with American export aviation gasoline except at the highest altitudes. The fuel economy of the Borneo gasoline may be said to have averaged about the same as that of American export aviation gasoline.

As regards the method of working up data, one feature of the lines of horsepower plotted against barometric pressure was particularly helpful. It was found that the intercepts of these lines on the axis of zero pressure were quite evenly spaced. For example, in the equation of the line

$$y = ax - b$$

wherein y = horsepower, and x = barometric pressure in cm. of

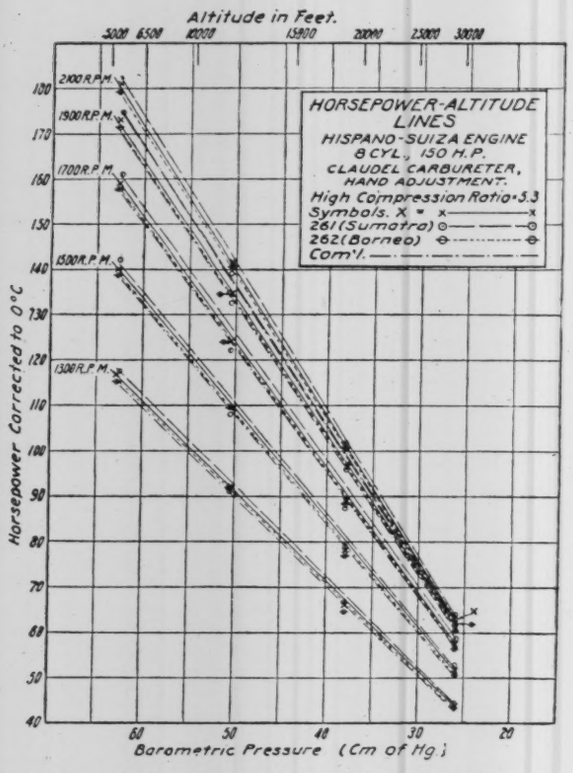


FIG. 5 DATA OF TESTS ON SUMATRA AND BORNEO GASOLINES AT THE BUREAU OF STANDARDS

mercury, the values of b increased by even increments for even increments of speed. The value of b is a function of the friction horsepower at that particular speed. Since the friction horsepower is entirely independent of the fuel employed, the values of b should be the same for each speed regardless of the fuel. Roughly estimating the equations of the various lines from the highest and the lowest horsepowers in each case showed that the values of b were approximately the same for all fuels. Plotting these values of b against speed and drawing an average line through these points gave the final values which were employed for the lines of Fig. 5.

The power characteristics of 20 per cent benzol mixture were also investigated by E. W. Roberts, the fuel consisting of benzol and gasoline. From the results of these tests the following conclusions have been drawn: This mixture shows very little gain in power as compared with aviation gasoline (export) at the lower altitudes and the lower speeds. There is very little gain in horsepower below 10,000 ft. Above this altitude, and at high engine speeds, the engine shows considerable gain in power, which at 29,300 ft. and 2100 r.p.m. is 5.8 per cent.

While the methods of measuring fuel consumption were not entirely satisfactory, the fuel consumption of the 20 per cent benzol mixture appears to be about 4 per cent greater than X, at speeds and powers where it gives its best performance. (*National Advisory Committee for Aeronautics* Report no. 47, preprint from 4th annual report, 35 pp., numerous curves, *eA*)

Neptune Diesel Engine; Novel Scavenging Valve Arrangement

BRITISH DIESEL ENGINE. Description of the Neptune Diesel engine built by Swan Hunter and Wigham Richardson, known as the constructors of the *Mauretania*.

The new engine is based essentially upon the Polar motor of the Atlas Diesel Engine Company of Stockholm, but embodies several new features. It operates on the two-stroke-cycle single-acting principle, but there is one scavenging pump for each working cylinder arranged directly below it; air at atmospheric pressure is drawn into it on the up stroke and compressed to about 3 lb. per sq. in. on the down stroke. The control of the air admission and its discharge into a scavenging trunk C, Fig. 6, is effected by means of the valve A, which is actuated from the camshaft by means of an eccentric and vertical link. From the scavenging trunks C and D, which act as reservoirs, the scavenging air enters the working cylinders through ports at the bottom when these are uncovered by the piston on its downward stroke, the top

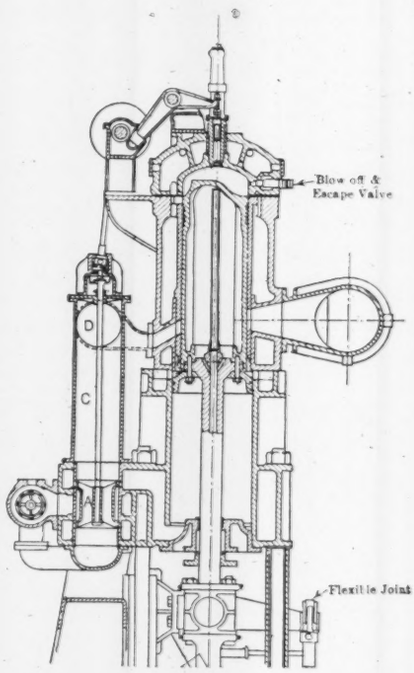


FIG. 6 CROSS-SECTION OF 1500-HP. NEPTUNE MARINE OIL ENGINE

of the piston being shaped in a special manner to help in the effective admission of the scavenging air and discharge of the exhaust gases.

The piston valve A in combination with a change valve (not shown, but located back of A) serves another purpose. The scavenging cylinders are here used for starting purposes, compressed air at the low pressure of 100 to 150 lb. per sq. in. being admitted below the scavenging piston through the change valve and the piston valve A.

This indicates the object of the change valves. On starting up, these valves are placed in such a position that the admission pipe to the atmosphere is closed, but open to the compressed-air

supply, so that compressed air passes through the piston valve *A* into the scavenging cylinders.

The change valves are of the rotary type and are operated by means of a lever from the control station so that on starting up compressed air is admitted until the engine fires, after which the valves are immediately changed over to allow air to be drawn into the scavenging cylinders from the atmosphere. Only one valve, the fuel-admission valve, is required in each cylinder cover, as scavenging takes place through ports.

The scavenging cylinders, by the way, are supported on cast-iron columns at the front and by vertical steel columns at the back, with diagonal columns to provide stiffness. A pair of columns carries a pair of cylinders which permits ready standardization in 4-, 6- and 8-cylinder models.

A 6-cylinder engine, 18-in. diameter and 36-in. stroke, running at 115 r.p.m., develops 1500 i.hp. (*International Marine Engineering*, vol. 25, no. 1, Jan. 1920, pp. 29-32, 2 figs., *d*)

MACHINE SHOP (See Abrasives)

MACHINE TOOLS

GEOMETRIC PROGRESSION OF SPEEDS IN MACHINE TOOLS, C. C. Stutz, Mem.Am.Soc.M.E. Presentation of a method of proportioning the speeds of machine tools which may be applied to almost any problem of this type.

In designing machine tools of any type it is now an accepted practice to so proportion the speeds that they will form among themselves a geometric progression, so that each speed is increased from the preceding speed by the same multiplier.

By multiplying the slowest speed a by the factor f, we obtain the second speed and so on through the whole series.

As a rule the number of speeds n is such that it cannot be obtained by a cone pulley alone, and the machine is therefore either back-geared or triple-geared, or perhaps even quadruple-geared. In such a case it is a simple matter to obtain these gear ratios, as will be shown.

Assuming as an example a lathe with a four-step cone, ($d = 4$), triple-geared. This would give us four speeds with cone, four speeds with cone and back gears, four speeds with cone and triple gears; or 12 speeds in all, and the series (from the fastest to the slowest speed) would be: af^{11}, af^{10}, af^{9}, af^{8}, af^{7}, af^{6}, af^{5}, af^{4}, af^{3}, af^{2}, af, a.

It will be noticed that these three sections of the full series (each forming a series) bear the following relation to each other:

1 The second series can be obtained by dividing each member of the first series by f^4. In this case f to the fourth power is the ratio of the back gears.

2 The third series can be obtained by dividing each member of the first series by $f^4 \times f^4 = f^8$. In this case f to the eighth power is the ratio of the triple gears.

As the actual calculations are best carried out by logarithms we can summarize the above by writing

the log of ratio of back gears $= d \log f$ ..... [2]

the log of ratio of triple gears $= 2d \log f$ ..... [3]

and the log of ratio of quadruple gears $= 3d \log f$ ..... [4]

Numerical examples of the application of these formulæ are given and also formulæ for the case of a machine with two crankshaft speeds and for dividing the speeds between the two crankshaft ratios. (*American Machinist*, vol. 52, no. 3, Jan. 15, 1920, pp. 117-118, *mp*)

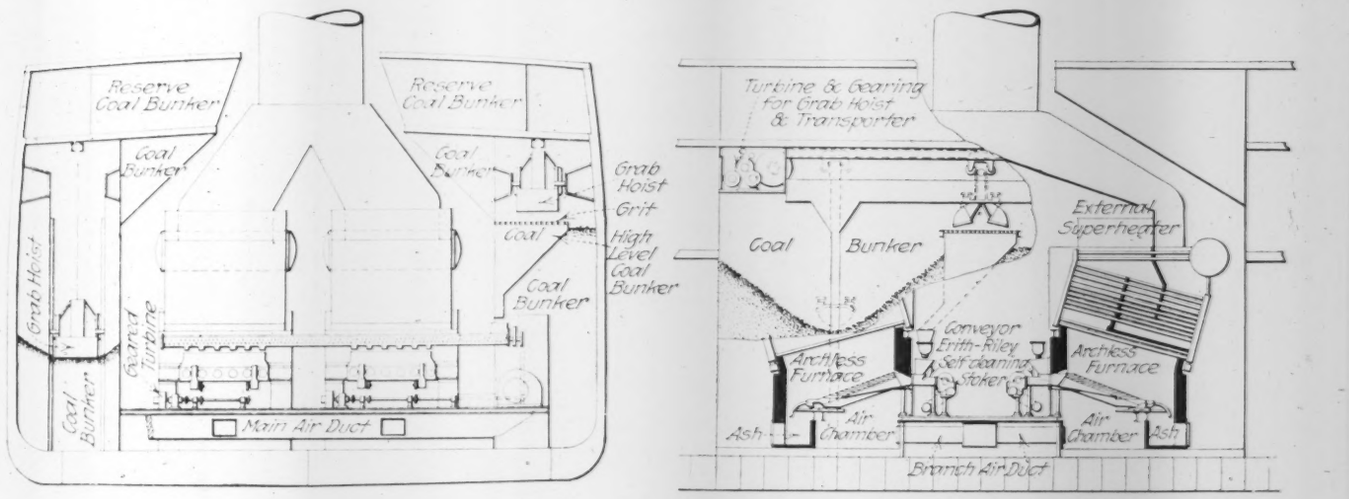


FIG. 7 RILEY MULTIPLE-RETORT STOKERS AND MECHANICAL COAL HANDLING AS INSTALLED BY ERITH, OF LONDON. INSTALLED ON NEW SHIPS ONLY

The writer assumes that the proper minimum speed a and maximum speed b for the given tool are given and that the total number of speeds desired n is also known. From this he derives the various speeds in the following manner.

Let n_1 = total steps or intervals between total number of speeds

f = ratio of one step or factor wherewith to multiply any speed to obtain the next higher speed, and

d = number of steps in cone pulley.

Algebraically expressed, the various speeds therefore form the following series:

$$a,\ af,\ af^2,\ af^3,\ af^4 \ldots\ldots\ldots\ldots af^{n-2}\ af^{n-1}$$

The last or fastest speed is expressed by both

$$af^{n-1} = b, \text{ or } f^{n-1} = \frac{b}{a}$$

$$f = \sqrt[n-1]{\frac{b}{a}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

MARINE ENGINEERING

Mechanical Stoking Aboard Ship, Its Technical and Economic Aspects

MECHANICAL STOKERS ABOARD SHIP, Charles H. Bromley. Progress of the application of mechanical stoking aboard ship. It is claimed that the introduction of oil fuel holds back their wider adoption at present. The adoption of mechanical-stoker feed aboard ship is clearly related to the introduction thereon of the water-tube boiler, and this latter is opposed in some quarters because of its alleged inferiority to the Scotch boiler in respect to reliability.

The author points out, however, that the experience of American war vessels and the vessels of the Emergency Fleet Corporation has shown that when properly handled the water-tube boiler is highly reliable and instances are given to prove this contention.

Fig. 7 shows an installation of Riley multiple-retort underfeed stokers such as carried out by the Erith Engineering Company of London. In this case it has been adapted to the Babcock & Wilcox-type cross-drum water-tube boiler built with tubes 14 ft. long, and the boilers are installed athwart ship.

Owing to the moderate continuous load very high combustion charges are not required, the long-pattern stoker operating at comparatively low combustion rates. The stoker, of course, cleans itself of ash; the coal is mechanically handled, making on shipboard an installation closely similar to a modern stationary steam plant. Furthermore, the equipment does not occupy as much space as the usually installed Scotch boiler of equivalent steaming capacity, and the weight is much less also.

The Emergency Fleet Corporation follows a somewhat different line of design, as one can see from Fig. 8. The characteristic feature of this type of installation is the baffling found by experiment with the assistance of the Bureau of Mines and claimed to enable getting the most heat out of the flue gases and into the boilers.

Here also plenty of room is provided for ash deposit and removal at the refuse end of the stokers (the coal-handling machinery is not shown).

These boilers are very much lighter for a given steaming capacity than the Scotch. The Heine boiler of 3100 sq. ft. heating surface, 225 lb. pressure, hand-fired, without grates but inclusive

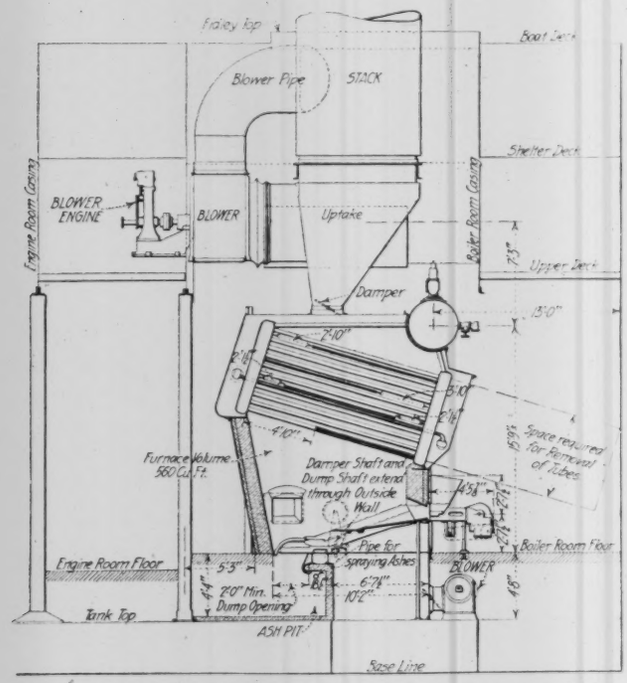


FIG. 8 GENERAL LAYOUT FOR WATER-TUBE BOILER AND RILEY MULTIPLE-RETORT STOKER FOR SHIPS OF EMERGENCY FLEET CORPORATION

of water, weighs 60 tons. The Scotch of 3032 sq. ft., 220 lb. pressure, weighs dry 68.48 tons and requires 29.62 tons of water, making a total of 98 tons, as against 60 tons for the water-tube. The 8000- to 10,000-ton ships of 11 knots speed need three such boilers. The saving in weight alone per ship is therefore appreciable.

While the mechanics of the application of mechanical stokers aboard ship has been fully developed by the engineers of the Emergency Fleet Corporation, the stokers will not be applied to the ships owing to the low price of fuel oil to the corporation. It is now somewhere in the neighborhood of 2⅛ cents a gallon, which puts coal out of the running. During the war, however, the Government had to pay from 7 to 9 cents per gallon of oil and it is now believed that the present low price will stay very long.

The navies of the world will use oil regardless of price. So, too, will fast passenger ships. It is believed by many that there is not enough oil to warrant its wide use in the merchant marine for many years, although within recent weeks rich oil finds are reported from Colombia. Just now American coal is selling in Italy for $36 a ton. The freight rate is $22. So it is not bad business now to use oil-burning ships in the coal trade to Europe. Yes, the mechanical stoker for ships is here, and when oil again becomes high-priced or its supply alarmingly diminished, it will come into its own. (*Power*, vol. 51, no. 3, Jan. 20, 1920, pp. 86-89, 8 figs., *dg*)

MILITARY ENGINEERING (See Testing and Measurements)

MOTOR-CAR ENGINEERING

Smith Gas Producer

PRODUCER GAS FOR MOTOR VEHICLES, D. J. Smith. General discussion of the advantages and disadvantages of the use of producer gas for motor vehicles, followed by a description of some attempts to do it on a practical scale—among others, those made by the author of the paper himself.

In the opinion of the author the ordinary producer is larger and heavier than it might be, and one of the reasons for this condition is that a very deep fuel bed is employed. To get away from this excessive weight the author resorted to the use of a thin bed of fuel which made it necessary to maintain two things: (1) a regular feed of fuel in small, measured quantities, and (2) continuous agitation of the whole fuel bed in order that no channels or holes in the fire might occur, and that all ash might be constantly sifted out and the fuel bed kept light and porous to give easy passage to the air and water vapor through it. In the producer used by the author the depth of the furnace chamber was approximately 12 in., the depth of fire being only 6 in., and it is stated that a producer with such a thin bed of fuel works very low, and that of anthracite, semi-anthracite and hard, non-caking steam coal only dust is found in the scrubber.

The feed and grate mechanism were driven by the engine of the vehicle, and a mechanical ash discharge was also added. This enabled a further reduction in the size of the producer by doing away with the necessity of providing an ashpan large enough to contain the ash formed during some hours' running.

As great flexibility in the operation of the producer was desired, it was found that water could not be fed directly to the fire which made it necessary to feed it as steam, and further, in order to keep the quality of the gas constant, the air passing to the producer had to be used as a regulating medium for the steam supply. A small vaporizer or boiler was therefore fitted to the producer heated by radiation through the fire and the passage of gas through a channel formed in it. (Figs. 9 and 10.)

The effect of varying level in the vaporizer due to the rolling of the vehicle on an uneven road was overcome by a device described in the original paper.

The producer as shown in Figs 9 and 10 was controlled only by the speed of the engine. A throttle was fitted to the air inlet to the vaporizer through which all air admitted to the producer had to pass. This throttle was coupled to the engine throttle, so that as the engine throttle was opened the throttle on the air inlet was partially closed. The result of this was to lower the boiling point of the water in the vaporizer, which then gave off steam freely owing to the drop in atmospheric pressure or slight vacuum to which it is subjected.

In addition to this, however, it was necessary to regulate the action of the producer also by the load on the engine, which was done by means of an arrangement in which the stroke of the fuel-feed device and that of the water pump were varied.

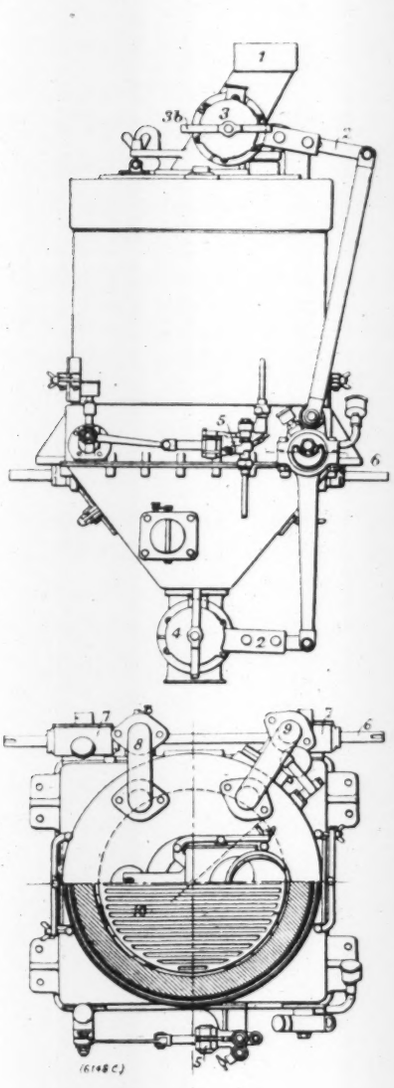
As regards the question of scrubbing, the device shown in Fig. 11 is claimed to have solved the problem of making it automatic. This device is in three sections: (1) the feed heater; (2) the cooling tubes; (3) the filter tubes.

The gas from the producer enters the top header at the left-hand end and passes down the internal tube of the feed heater, which at the lower end is coned, and this tends to increase the velocity of the gas. The gas then expands into a settling chamber or pot, and in doing so drops a very large percentage of dust in suspension. It then leaves the settling chamber by an annular passage and passes up and down two or more banks of cooling tubes. In these tubes and the headers more dust is deposited. Finally, the gas passes up two or more large-diameter tubes, which are fitted with fine-gauze filters of conical shape and filter fitting the bore of the tube at the lower end; to this a cross-handle is attached, which allows the filter to be easily withdrawn through the door in the top header. An arrangement is also provided whereby any filter can be closed off and withdrawn for cleaning without stopping the action of the producer, but this is not likely to be required for vehicle work. The gas on leaving the filters is clean enough for all practical purposes and carries no more dust than is drawn into the air inlet of a carbureter when the roads are dusty. The cleaning of the filter is simple and only takes two or three minutes. The doors are opened, the gauze filters withdrawn and water is poured in at the top doors and all dust washed out; the gauze filters are then shaken and replaced. The water from the feed pump on the producer enters the feed heater at the bottom opening and leaves at the top of the vaporizer. This cools the gas considerably, and also recovers much valuable heat which would otherwise be lost. The combined feed heater and filter is very small and can be easily accommodated on the dashboard on the side opposite to the producer. Many other forms of filters will, no doubt, be possible, but the author thinks it will be difficult to evolve a design which at once meets the requirements and is of less weight and size.

The material found in the filter is merely the fuel dust, which is quite dry and clean, and no trace of any tarry substance likely to cause trouble with the engine has ever been found.

The mixing valves and refractory lining of the producer are described in some detail. As regards the weight of the producer, it is stated that the plant which has a grate 12 in. in diameter, equivalent to 50 hp., weighs with its connections approximately 2.75 cwt. (308 lb.), corresponding to a weight of 6 lb. per hp., notwithstanding the fact that cast iron was used throughout. This does not include, of course, the weight of the engine itself, but only that of the producer and its appurtenances.

As regards the engine design, the author states that the conventional gasoline engine is entirely unsuitable for use with producer gas. With such a cheap fuel a large, comparatively slow-running engine could be used with approximately the same characteristics as a stationary engine. A higher compression with a half-compression device is essential, as a pressure of 120 to 150 lb. gage would be necessary to obtain a fair economy with producer gas. The author recommends, for example, an engine such as the four-cylinder stationary type, 6½ in. diameter by 7½ in. stroke, running at 600 r.p.m.



1. Fuel inlet pipe.

2. Adjustable fuel feed and ash-discharge gear.

3. Fuel feed valve.

3a. Friction drive for feed valve.

3b. Handle for independent hand operation of feed valve.

(Note that the position of the handle indicates the location of the feed aperture.)

4. Ash discharge valve.

4a. Friction drive for ash discharge valve.

4b. Handle for ash discharge valve. (Similar to that on fuel feed valve.)

5. Water pump.

6. Main operating gear shaft driven direct from engine.

7. Totally enclosed and continuously lubricated driving gear for the fire-bar camshafts, these also drive the water pump, fuel feed valve and ash discharge valve.

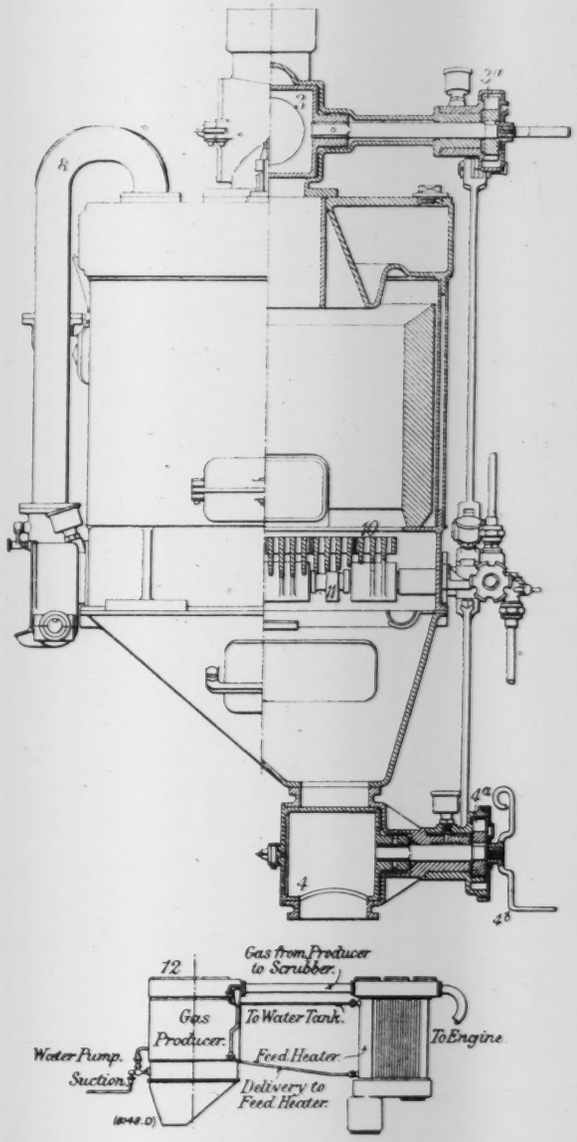
8. Pipe conveying steam and air to the underside of the fire.

9. Air supply pipe from interior of jacket to vaporiser.

10. Fire bars, alternate sections pivoted at alternate ends, the free ends being vibrated section by section and successively by cams on revolving shafts.

11. One of the cams for vibrating the fire-bars.

12. Diagrammatic arrangement of producer and scrubber.



FIGS. 9 AND 10 GENERAL ARRANGEMENT OF THE SMITH PORTABLE GAS-PRODUCER PLANT

As regards fuels, the author tested anthracite, semi-anthracite, coke, charcoal, peat, corncobs and straw, all of these fuels proving satisfactory under certain conditions.

In an editorial article on page 85 of *Engineering* for January 16, 1920, attention is called to the fact that in the paper no information is given as to the degree of reliability to be expected from the system described by Mr. Smith, a point which would be of interest to prospective users, especially if they had had experience with stationary producer plants. (Paper read before the Institution of Automobile Engineers, Jan. 8, 1920, abstracted through *The Automobile Engineer*, vol. 10, no. 134, January 1920, pp. 22-32, 9 figs., and *Engineering*, vol. 109, nos. 2819 and 2820, Jan. 9 and 16, 1920, pp. 59-64 and 92-95, 9 figs., *dA*)

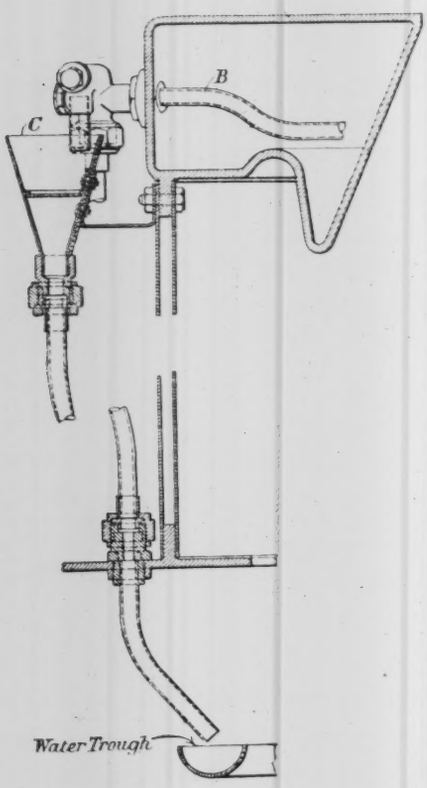


FIG. 11 SCRUBBER FOR THE SMITH GAS-PRODUCER PLANT

Single-Sleeve Duplicated-Piston V-Type Motor

DUPLEX CAR AND ENGINE. Description of a light British car with an unusual type of engine.

The Duplex motor, Fig 12, is of the single-sleeve duplicated-piston type with the pistons running in conjointly twinned cylinders, and consists of a detachable headed monoblock of 8 cylinders of only 56 mm. (2.20 in.) bore by 75 mm. (2.95 in.) stroke.

The ports, inlet and exhaust are cut half around the outer side of each cylinder and are opened and closed by crankshafts through tiny connecting rods attaching to lugs at the bases of the sleeves (Fig. 13). These sleeves, which are of cast iron, carry three rings each, the top one wider than the other two, and as the ports are 5/16 in. deep on the exhaust side and ¼ in. deep on the inlet, the construction gives a large valve area with a comparatively slight sleeve motion (1⅛ in.).

The pistons carry their three rings in the middle of their trunks and the gudgeons are rather lower than usual, because of the connection in each pair to a common crankpin on the short four-throw crankshaft.

The crankshaft is mounted at the ends only in two roller bearings, the rollers being hollow to enable them to be link-caged and distanced somewhat like the rollers in a chain. The sleeve shafts, on the other hand, are mounted in long plain bearings with bolt thrusts at the end and drive is by helical gearing from the front end of the crankshaft. The sleeve shaft also carries an eccentric actuating a horizontal piston pump internally spring-loaded, which draws oil from a large deep rearward sump by way of a non-return ball valve (right-hand side of Fig. 13) and delivers it downward again to a gallery lead in the casting for distribution to four transverse troughs from which dippers on the big ends effect splash lubrication to all interior surfaces.

It is claimed that this design permits obtaining rather interesting physical results; namely, a cylinder capacity of approximately 80 mm. (3.15 in.) by 75 mm. (2.95 in.) halved in area so as to produce a simultaneous effort under the medium long stroke or "internal combustion" conditions of 56 mm. (2.20 in.) by 75 mm. (2.95 in.). It is claimed that in this manner all the capacity of the short-stroke type is obtained for sustained high speed without its extravagance and jerky inflexibility at low and medium speeds. In fact, it is claimed that a motor is obtained in which the power curve is practically a straight line from the rated 10 hp. at 1000 r.p.m. up to 33 hp. at 3000 r.p.m.

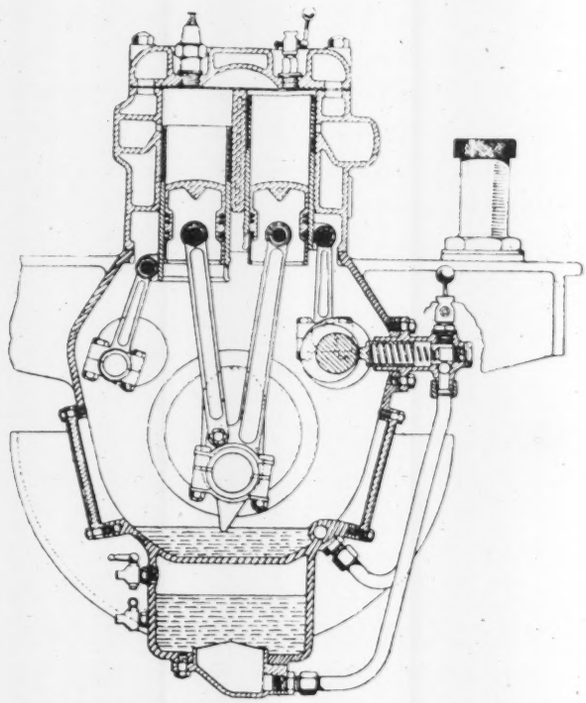


FIG. 12 DUPLEX SLEEVE-VALVE MOTOR, PLAN VIEW WITH HEAD BLOCK DETACHED, SHOWING THE SEMI-CIRCUMFERENTIAL PORT AREAS

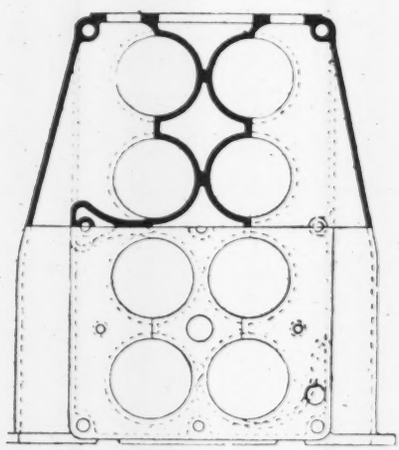


FIG. 13 DUPLEX SLEEVE-VALVE MOTOR, SECTIONAL END VIEW FROM THE FRONT

As regards the valve mechanism, it is stated that the valve shafts having only frictional resistance to overcome are doing next to no work and their rotation absorbs little power, while the system affords easy timing. It is claimed the motor presents unusually good cooling facilities. (*The Auto Motor Journal*, vol. 25, no. 3/993, Jan. 15, 1920, pp. 66-68, 7 figs., *dA*)

POWER-PLANT ENGINEERING

Suggested Form of Reporting Steam Power-Plant Performance to Give Comparable Data

ESSENTIAL STATISTICS FOR GENERAL COMPARISON OF STEAM-POWER-PLANT PERFORMANCE, W. S. Gorsuch. Method for preparing statistical reports relating to power generation in steam power plants based on coal and load characteristics of the plant; suggested tabular forms for reports.

The principal difficulty with operating statistics of steam power plants as published by various state and government bodies, is that they are inadequate for the purpose of determining the efficiency of a plant or making general comparisons between different plants. Bare figures of coal consumption per kw-hr. are given without information as to the quality of the coal and data as to the character of the load on the station. When load factors are given the figures are misleading, because they are computed upon different bases; thus, gross output is used in some cases and net output in others.

The author recommends that the following items be recorded in statistical reports relating to power generation in steam power plants and that they be expressed in a uniform manner. These items are said to reflect the influence of station design and arrangement of apparatus, methods of operation and management, load, quality and kind of fuel used and also indicate the character of the load imposed upon the station.

I Coal Characteristics of the Plant:

1 Average B.t.u. supplied to plant per kw-hr. net output.
2 Thermal efficiency of plant in per cent
3 Average B.t.u. per dollar, coal as received (moist basis)
4 Coal factor or pounds of coal per kw-hr. net output (moist basis)
5 Average B.t.u. per pound of coal as received (moist basis)
6 Cost of coal per ton (2240 pounds) delivered alongside of the plant
7 Kind and character of coal
8 Cost of coal in cents per kw-hr. net output.

II Load Characteristics of the Plant:

9 Average daily load factor of load
10 Maximum load for the year
11 Yearly load factor of load

(Interval of maximum load 15 min. or 1 hour depending upon character of load.)

12 Kilowatt-hours net output for the year (kilowatt-hours sent out from the a.c. bus)
13 Installed rated capacity, that is, the aggregate maximum continuous rating of the generators in kilowatts
14 Average kilowatt-hours net output per kilowatt installed rated capacity.

Items 1, 2, 3, 8, 11 and 14 can readily be computed from items 4, 5, 6, 10, 12 and 13.

As regards the coal characteristics, generally speaking, the highest thermal efficiency is obtained when burning the highest quality of coal. On the other hand, a low grade of coal purchased at a low price may result in a better commercial efficiency. Therefore, as an index of the commercial efficiency of the plant, one has to have both the B.t.u. per kw-hr. net output and the B.t.u. per dollar.

The character of the load carried has a marked influence on plant efficiency since a fluctuating load and a load with sharp peaks and low load factor require more coal than an equally steady load or a load with a high load factor. The load conditions must therefore be known in order to compare the performance of the two plants, and these are best indicated by the ratio of the average load to the maximum load for the same period; this is known as the load factor and is usually expressed in percentages.

There is, however, in the electrical industry no uniform method for determining the load factor. The writer recommends the use of the daily load factor which is the ratio of average net output during 24 hr. to the net maximum load multiplied by 100 in order to express the load factor in percentages. In comparing power-station statistics, which are usually on a yearly basis, the average daily load factor should be used because it is more representative of the operating conditions in the plant itself than the load factor based on the maximum of the month or year. The plant factor, which is the ratio of the average hourly load for the year to the rated capacity of the plant, is a measure of the utilization of the installed capacity. This is obtained by dividing 8760 into item 14.

For the purpose of illustrating the method and advantages for preparing statistical reports as described here, the following comparison is made between a few of the items of two plants, A and B, which have similar load characteristics but which use coal differing in quality and price:

		Plant A	Plant B
I	Coal Characteristics of the Plant:		
1	Average B.t.u. supplied to plant per kw-hr. net output	22,400	25,600
2	Thermal efficiency of plant in per cent	15.24	13.34
3	Average B.t.u. per dollar, coal as received (moist basis)	5,226,666	5,734,400
4	Coal factor, or lb. of coal per kw-hr. net output (moist basis)	1.60	2.00
5	Average B.t.u. per lb. coal, as received (moist basis)	14,000	12,800
6	Cost of coal per ton (2240 lb.) delivered alongside plant	6.00	5.00
7	Kind of coal	Bituminous	Bituminous
8	Cost of coal in cents per kw-hr. net output	0.428	0.446
II	Load Characteristics of the Plant:		
9	Average daily load factor of load (Interval of maximum load, 1 hr.)	50	54
10	Maximum load of the year (Interval of maximum load, 1 hr.)	90,000	80,000
11	Yearly load factor of load (Interval of maximum load, 1 hr.)	40	38
12	Kw-hr. net output for the year (kw-hr. sent out from the a.c. bus)	315,460,000	217,248,000
13	Installed rated capacity, i.e., aggregate max. continuous rating of the generators in kw	125,000	100,000
14	Average kw-hr. net output per kw. installed rated capacity	2.525	2.173

(*Journal of The American Institute of Electrical Engineers*, vol. 39, no. 2, Feb. 1920, pp. 132-134, *p*)

PRODUCER GAS (See Motor-Car Engineering)

TESTING OF MATERIALS (See Engineering Materials)

TESTING AND MEASUREMENTS

Theory of Rocket Action: Goddard's Calculation of Rocket Capable of Passing Beyond the Range of Attraction of the Earth

A METHOD OF REACHING EXTREME ALTITUDES, Robert H. Goddard. Discussion of rocket action, the theory and design of rockets, and also the use of rockets for carrying recording instruments to the upper reaches of the atmosphere and beyond.

The problem considered in the paper was to determine the minimum initial mass of an ideal rocket necessary in order that on continuous loss of mass a final mass of 1 lb. would remain at any desired altitude.

An approximate mathematical method has shown that surprisingly small initial mass would be needed to carry a rocket to extremely high altitudes provided the gases were ejected from the rocket at a high velocity and also provided that most of the rocket consisted of propellant material.

The reason for this is, namely, that the velocity enters in the expression for the initial mass as an exponent, so that if the velocity of the ejected gases be increased fivefold, the initial mass necessary to reach the given height will be reduced to the fifth root of that required for the lesser velocity.

The solution of the problem of constructing a rocket of reasonable dimensions to reach extremely high altitudes necessitated the determination of the extent to which efficiency could be carried in a rocket of new design. The term efficiency as applied to rockets means the ratio of kinetic energy of the exploded gases to the heat energy of the powder, the kinetic energy itself being calculated from the average velocity of ejection—obtained indirectly by observations on the recoil of the rotors.

Tests have shown that the powder used in an ordinary rocket constitutes only a very small fraction of the total mass and the efficiency of the rocket is as low as 2 per cent. Experiments were performed with the object of increasing the average velocity of ejection of the gases. Charges of dense smokeless powder were fired in steel chambers provided with smooth tapered nozzles, the object of which was to obtain the work of expansion of the gases, much as is done in the DeLaval steam turbine. The efficiencies and velocities obtained in this way were very high, the highest efficiency being over 64 per cent and the highest average velocity of ejection being slightly under 8000 ft. per sec. Moreover, these velocities were proved to be real velocities and not merely effects due to reaction against the air resulting from firing the same steel chambers in vacuum and observing the recoil.

Since, however, a heavy steel chamber could not be used in a rocket, a reloading mechanism was designed in which successive charges were fired in the same chamber of light weight and small mass, so that most of the mass of the rocket could consist of propellant.

Regarding the heights that could be reached by the above method, it would appear that a mass of 1 lb. could be elevated to altitudes of 35, 72 and 232 miles by employing initial masses of from 3.6 to 12.6, from 5.1 to 24.3 and 9.8 to 89.6 lb., respectively, which is only a very small fraction indeed of what the initial masses would have to be in order to raise to the same heights a rocket of the Costen ship type.

In the course of the investigation several interesting methods were developed for deducting and measuring gaseous rebound; one to measure the force of the rebound, and another, called "impulse motors," for measuring the magnitude per unit area produced by the rebound in gases.

Among other things is discussed the question of calculating the minimum mass required to raise 1 lb. to an infinite altitude. The meaning of this term is as follows: Theoretically a mass projected from the surface of the earth with a velocity of 6.95 miles per sec. would, neglecting air resistance, reach an infinite distance after an infinite time, which in ordinary language means that it would never return to the earth. Actually, such a mass would not reach an infinite distance, but would come under the gravitational influence of some other heavenly body and follow the course prescribed by the resultant between the two forces acting upon it.

The construction of a rocket that would pass the sphere of gravitational attraction of the earth does not appear to present insuperable difficulties, the main difficulty lying in the finding of means of proving that such extreme altitudes as would be considered in this case had been reached. The only reliable procedure would be to send the smallest mass of flash powder possible to the dark surface of the moon when in conjunction in such a way that it would be ignited on impact. The light would then be visible in a powerful telescope.

Mathematical computations have shown that with the telescope of 1 ft. aperture a mass of flash powder of about a dozen pounds exploded on the surface of the moon would be very clearly visible, but to carry such a mass of flash powder to the moon a rocket of an initial mass varying between 8 and 16 tons would be needed.

The author of the paper plainly states that this plan of projecting a mass of flash powder to the surface of the moon, although a matter of much general interest, is not of obvious scientific importance. He adds that there are, however, developments of the general method under discussion which involve a number of important features not herein mentioned which could lead to results of much scientific interest. These developments involve many experimental difficulties but they depend upon nothing that is really impossible.

It appears, therefore, that contrary to the impression given by newspaper reports of the paper, the author does not consider that his rockets in their present stage can be employed for establishing a system of passenger transportation between our planet and its heavenly neighbors. (*Smithsonian Miscellaneous Collections*, vol. 71, no. 2, publication 2540, 1919, 69 pp. and 10 plates of figures, *te*.)

VARIA

NEW BRITISH PATENT ACT. This act was finally approved on December 23, 1919, and is now in force, except a few sections. It makes numerous alterations and amendments to the act of 1917, the most important of which are as follows:

The period of provisional protection has been increased from six to nine months. The duration of the life of a patent has also been extended and is now sixteen years instead of fourteen, as hitherto.

Provisions have been made to simplify the procedure for obtaining the prolongation of the life of the patent when it has been affected by war conditions.

An important alteration of the previous laws has been made in the way of extending the ground of opposition to the grant of a patent so as to include prior publications other than patent specifications, which makes it possible to now use references to newspaper or technical periodicals. But the examiner is not allowed to cite publications other than British specifications in opposition to the grant of a patent.

Under the new laws an inventor does not prejudice his right to a patent if he reads a paper containing a description therein before a learned society and has before such reading given notice of his intention to do so.

Extensive modifications not suitable for abstracting have been made in the closes referring to the working on a commercial scale of new inventions required under the patent laws. The system of granting compulsory licenses has also been modified in several material respects. On the whole, however, the old provisions as to the method of payment, etc., which made the British system so different from the American have been maintained in their most essential records. (Compare *Engineering*, vol. 109, no. 2819, Jan. 9, 1920, pp. 53-54, *g*)

WOMEN WORKERS IN BRITAIN. Approximately 5000 firms in Great Britain have been asked by the Women's Industrial League for a statement of their experience of women as industrial workers. Over 1400 replies have been received, covering a wide field in engineering and other trades.

The replies show that 1422 firms were employing 79,700 women at the end of May, 1919, as compared with 43,200 before the war and 245,300 during the war. Of 382 firms who employed women before the war, 67 propose to increase the number, in consequence of the larger experience of women's work gained by them; while of 764 who employed women for the first time during the war, 228 propose to retain them. These firms do not comment on the present labor situation. A further 97 firms state that they would be willing to retain women but for trade union opposition. Taking all the figures, the estimate is that over 60 per cent of those who have tested women's work are ready to continue employing them. (*The Iron Trade Review*, vol. 66, no. 8, February 19, 1920, p. 558, *g*).

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

Research Associations in Great Britain

THE proposed Research Associations in Great Britain which were described in the letter of Mr. Bancel in MECHANICAL ENGINEERING for August have been organized, and a recent circular issued from the Department of Scientific and Industrial Research of Great Britain gives the following list of Associations which have received licenses from the Board of Trade:

British Boot, Shoe and Allied Trades Research Association, Technical School, Abington Square, Northampton. Secretary, John Blakeman, M. A., M. Sec.

British Cotton Industry Research Association, 108, Deansgate, Manchester. Secretary, Miss B. Thomas.

British Empire Sugar Research Association, Evelyn House, 62, Oxford St., London, W. 1. Secretary, W. H. Giffard.

British Iron Manufacturers Research Association, Atlantic Chambers, Brazenose Street, Manchester. Secretary, H. S. Knowles.

British Motor and Allied Manufacturers Research Association, 39, St. James Street, London, S. W. 1. Secretary, Horace Wyatt.

British Photographic Research Association, Sicilian House, Southampton Row, London, W. C. 1. Secretary, Arthur C. Brookes.

British Portland Cement Research Association, 6, Lloyd's Avenue, London, E. C. 3. Secretary, S. G. S. Panisset, A.C.G.I., F.C.S.

British Research Association for the Woolen and Worsted Industries, Bond Place Chambers, Leeds. Secretary, Arnold Frobisher, B. Sc.

British Scientific Instrument Research Association, 20, Russell Square, W. C. 1. Secretary, J. W. Williamson, B. Sc.

British Rubber and Tyre Manufacturers Research Association, c/o Messrs. W. B. Peat & Co., 11, Ironmonger Lane, E. C. 2.

The Linen Industry Research Association, 3, Bedford St., Belfast. Secretary, Miss M. K. E. Allen.

Glass Research Association, 7, Seamore Place, W. 1. Secretary, E. Quine, B. Sc.

British Cocoa, Chocolate Sugar Confectionary and Jam Trades Research Association, 9, Queens Street Place, E. C. 4. Secretary, R. M. Leonard.

The Department of Scientific and Industrial Research of Great Britain has approved certain research associations which have not yet been licensed by the Board of Trade. These associations are given in the list below:

British Music Industries Research Association
British Refractory Materials Research Association
British Non-Ferrous Metals Research Association
Scottish Shale Oil Research Association.

The associations which are being considered by the Department of Scientific and Industrial Research are listed below:

British Launderers Research Association
British Electrical and Allied Industries Research Association
British Aircraft Research Association.

The silk manufacturers, the leather trade and the master bakers and confectioners are preparing articles of association for consideration by the Department.

Do the lists above suggest to our members the advisability of the formation of similar research associations in this country? The Heating and Ventilating Engineers, the National Canners' Association, the Association of Steel Manufacturers are all indicative of such work in America, but there is need for more coöperative work. The Research Committee feels that we will have accomplished much when those engaged in similar lines of manufacture can forget trade differences and coöperate in all active work for the development of knowledge in science and the arts.

Kansas State Research Council

The State of Kansas has recently organized the Kansas State Research Council, which bears the same relation to the State of Kansas as the National Research Council does to the United States. Professor G. C. Shaad of the University of Kansas and Dean A. A. Potter of the Kansas State Agricultural College are on the Executive Committee of the Council.

Research of the American Society of Heating and Ventilating Engineers

The first reports of the researches from the Research Laboratory of the American Society of Heating and Ventilating Engineers at the laboratory in Pittsburgh under the direction of Director John R. Allen were made at the annual meeting of the society in January. A paper on the total heat transfer through radiators and the amount of radiant heat from a radiator, as well as the tests on coal stoves made by Professor Allen and Mr. Rowley, were given. The excellent work of this society as shown in these reports is highly commendable, and the Research Committee of The American Society of Mechanical Engineers greatly appreciates their activity.

Instrument Specifications

The Firestone Tire and Rubber Company are preparing a code of specifications for Bourdon tube pressure gages, recording thermometers, indicating mercurial thermometers and test gages. These are being prepared under the direction of Mr. F. J. Schlink, Physicist in Charge of the Instruments Inspection Department, and Chairman of the Special Committee on the Permanency and Accuracy of Indication of Engineering Instruments of The American Society of Mechanical Engineers.

A—RESEARCH RESULTS

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulae or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Apparatus and Instruments A2-20 The investigation on altitude effect of air-speed indicators is nearing completion and show conclusively that the compressibility of air may be legitimately omitted in determining the law of action of the usual venturi tubes; that viscosity must not be neglected in low-speed flights; that at low speeds the indication of the venturi is not directly proportional to the air density nor to the square of the speed but departs noticeably from this relation. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Cement and Other Building Materials A1-20 Crushed-Slag Aggregate. Crushed slag as a coarse aggregate produces concrete of as high or higher strength than gravel. The experiments already made are not extensive enough to determine the durability of slag, but so far as they have been carried on there have been no signs of disintegration due to sulphide sulphur. Slag sand does not produce an easily workable concrete when used as fine aggregate because of its lack of fine material. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Explosives and Explosions A1-20 Propagation of Flame in Pipes and Effectiveness of Arresters. The Underwriter's Laboratory of Chicago has issued a report on the above subject prepared by A. H. Nuckolls for the E. I. du Pont de Nemours and Company. The investigation was made by filling a pipe with a vapor-air mixture containing a known percentage of vapor and igniting by electric spark. The pressures developed were measured by recording gas-engine indicators and the effectiveness of arresters was determined by examining the products remaining in the pipe. The speed of propagation was not investigated. The results show that the pressure is dependent on the nature of the vapor and the relative proportion of air and is influenced by the size

and length of the pipe. Gasoline and ether produced maximum pressures from 75 lb. per sq. in. in ½-in. pipes to about 150 lb. per sq. in. in 6-in. pipes. Alcohol and acetone gave 50 to 100 lb. per sq. in. while amyl acetate and light oil gave about 70 lb. Rich and lean mixtures gave lower pressures than the mixture having the right composition for complete combustion. Pressures were found to increase with the diameter of the pipe but not with the length of the pipe. The propagation appeared to be progressive combustion. Arresters of the screen type were found to be more satisfactory than glass, wool or metal chips. Forty mesh, No. 31, B. & S. brass wire gave the best result, especially when made in the cone shape, the length of the axis being twice the diameter of the base. Multiple coarse-mesh screens were ineffective. The effectiveness of arresters is influenced by the nature and proportion of the vapor, size and length of pipe and location of arrester. Flames from ether and gasoline are more difficult to arrest than those from other vapors. The larger the amount of air the more easily is propagation arrested. In large pipes the arresters are not as effective as in small pipes.

In connecting tanks the connecting pipe should not be over 4 in. in size; preferably it should be ½ in. or 1 in. The length should not be greater than 20 ft. Double cone screens should be employed. Flat screens may be used in 2-in. vent pipes.

This investigation should be continued over a wider range. Address Engineering Department, E. I. du Pont de Nemours Company, F. A. Wardenburg, Assistant Chief Engineer, Wilmington, Del.

Heating A1-20 Coal Stoves. The efficiency of the standard design of base-burner coal stoves has been found to be about 70 per cent under ordinary operation. The two stoves tested showed an excessive amount of air leakage so that the percentage of CO_2 in the exhaust gases was about 4 per cent. After leaks were sealed the percentage rose to 10 per cent. The stove under ordinary conditions gave about 75 per cent efficiency, but at the higher rates of combustion it is impossible to get this efficiency due to the lack of radiating surface from which the heat can be given. The tests were made at the University of Minnesota by Professors John R. Allen and F. B. Rowley. Address John R. Allen, Bureau of Mines Building, Pittsburgh, Pa.

Heating A2-20 Radiant Heat from Direct Radiators. Director John R. Allen and Prof. Frank B. Rowley have presented a paper to the American Society of Heating and Ventilating Engineers on tests made at the University of Minnesota to determine the amount of heat radiated from a direct cast-iron steam radiator. The radiator was placed within a tank from which the air was exhausted and the amount of heat radiated was determined from steam condensation, measuring the heat input in an electrically heated boiler. The experiments indicate that the Stefan-Boltzmann law holds. The amount per sq. ft. of radiation is equal to

$$Q = 0.157\ R \left[\left(\frac{T_s}{100} \right)^4 - \left(\frac{T_r}{100} \right)^4 \right]$$

In this formula Q represents the heat in B.t.u. per sq. ft. per hour radiated from the radiator. R is the proportion of the total radiator surface which is effective in radiating heat. This varies from 0.55 in one-column radiators to 0.33 in four-column radiators, with a value of about 0.8 for wall radiators. The constant 0.157 was determined from physical experiments on clean cast iron, the value being less than this when aluminum paint is used. Table 1 gives the values of the constant D which is 0.15 in the formula above.

TABLE 1.

Condition of surface:	Temp. of tank surface, deg. fahr.	Temp. of steam, deg. fahr.	B.t.u. per sq. ft. radiating surface.	Value of constant D.
Cast iron, rusty.....	70	215	180	0.142
Cast iron, painted black.	70	215	152	0.130
Cast iron, clean.....	70	215	186	0.148
Aluminum paint	70	215	131	0.104
Physical experiment, clean cast iron.....	70	215	198	0.157

For practical work the authors suggest 0.157 be used in problems. With steam temperature at 215 deg. fahr. and room temperature at 70 deg. fahr. the radiation amounts to 200 B.t.u. per sq. ft. of rated surface per hour. Address Director John R. Allen, Bureau of Mines Building, Pittsburgh, Pa.

Heating A3-20 Heat Transfer from Direct Radiators. Director John R. Allen of the Research Laboratory of the American Society of Heating and Ventilating Engineers has presented a paper to the Society at its annual meeting January, 1920. His investigations show that the heat transfer from radiators is made up of two parts; that transmitted by radiation and that transmitted by conduction. The final formula is given as

$$Q = 0.157\ R \left[\left(\frac{T_s}{100} \right)^4 - \left(\frac{T_r}{100} \right)^4 \right] + (t_s - t_r)$$

In this equation the first terms give the heat delivered by radiation and the last term the heat by convection the constant for which is unity. In the equation Q represents the B.t.u. per sq. ft. of total radiator surface per hour. R represents the ratio of the radiating surface to the total surface. T_r = the absolute temperature of the room in fahrenheit degrees and T_s the absolute temperature of the steam in fahrenheit degrees, while t_r and t_s are in degrees fahrenheit. The value of R for ten-section radiators is about 0.55 for one-column radiators, 0.50 for two-column radiators, 0.38 for three-column radiators, 0.33 for four-column radiators and about 0.8 for wall radiators. These constants vary with the height of the radiator and with the number of sections in the radiator, increasing with the decrease of height and decrease of number of sections. Curves and tables show the effect of heights of radiator, widths of radiator, lengths of radiator, temperature of steam and room, humidity, air circulation, final painting and position of radiator. The results are

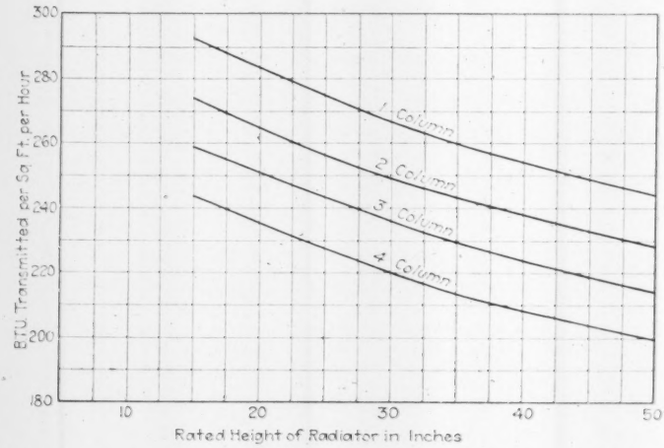


FIG. 1 HEAT TRANSMISSION FOR DIFFERENT HEIGHTS AND NUMBERS OF COLUMNS OF RADIATORS

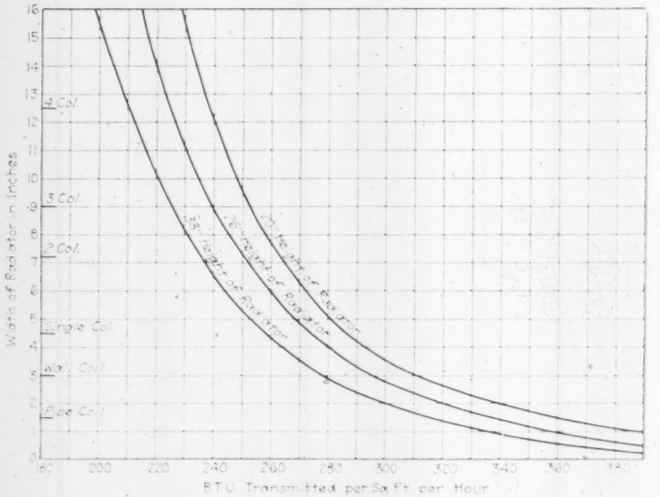


FIG. 2 HEAT TRANSMISSION FOR DIFFERENT WIDTHS OF RADIATORS

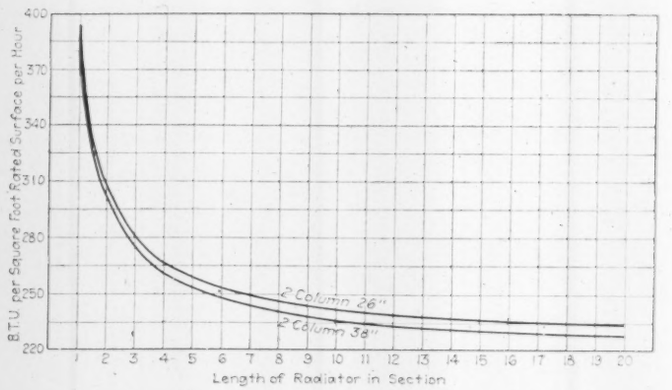


FIG. 3 HEAT TRANSMISSION FOR RADIATORS OF VARYING LENGTH

given in curves and tables in the original paper and the curves are reproduced below. The effects of grillwork or shields in front of the radiator are shown to reduce the heating capacity from 10 to 20 per cent, although when radiators are placed below seats reductions amount to 35 or 40 per cent. Address John R. Allen, Director, Bureau of Mines Building, Pittsburgh, Pa.

TABLE 2 EFFECT OF PAINTING ON TWO-COLUMN 38-IN RADIATOR

Steam Temperature 215 deg. Room Temperature 70 deg. fahr.

Condition of surface.	B.t.u. per sq. ft.
Cast iron, bare	240
Painted with aluminum bronze	200
Painted with gold bronze	205
Painted with white enamel	242
Painted with maroon japan	240
Painted with white zinc paint	242
Painted with no-luster green enamel	230

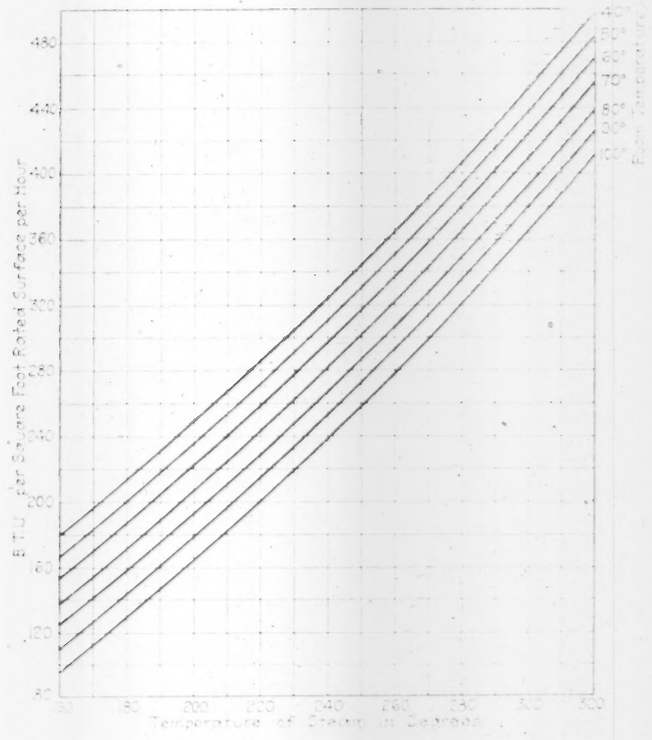


FIG. 4 HEAT TRANSMISSION FOR VARIOUS TEMPERATURES OF STEAM IN RADIATOR AND AIR IN THE ROOM

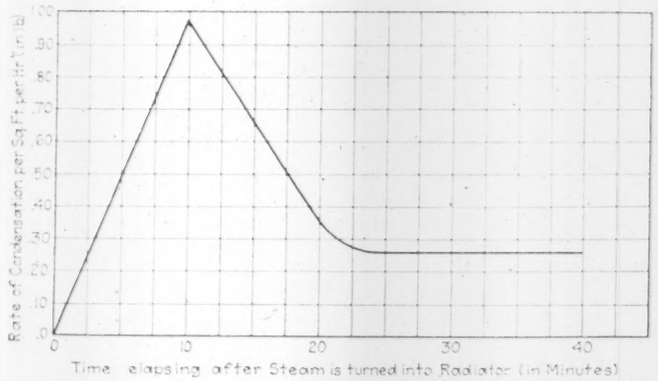


FIG. 5 RATE OF CONDENSATION WHEN STEAM IS TURNED INTO RADIATOR

Heating A4-20 Kiln Coils for Wood Drying. Return-bend heating coils gives a more uniform distribution of heat in kilns than coils built up of headers and should be used when possible. Forest Products Laboratory, Address Director, Madison, Wis.

Machine Design A1-20 Six-Throw Automobile Crankshafts. A report has been issued by the Bureau of Standards to certain manufacturers on the elimination of certain difficulties in making 6-throw automobile crankshafts. It was found that much of the trouble was of a mechanical rather than a metallurgical nature. Opportunities were found for improvements in the metallurgical treatment of the process. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography A2-20 Microstructure of Steel Subject to Sudden Heating. Martensite structure has been observed in the superficial layers of metal in the bores of guns and pressure plugs. This has been probably due to rapid heating and high temperature followed by sudden cooling. This has been shown to be true by a sudden heating and cooling of the metal produced by the intermittent discharge of an electrode close to the metal surface. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography A3-20 Spiegeleisen. Production of Spiegeleisen in Blast Furnaces, by P. H. Royster. War Minerals Investigations Series No. 6, Bureau of Mines. Address Van H. Manning, Director.

Properties of Engineering Materials A2-20 Fatigue Tests on Tubing. Tests in progress on iron and copper tubing under repeated stress indicate that pipes are seriously weakened by surface irregularities, especially by makers' names stamped on the pipe. Bureau of Standards, Washington, D. C. Address W. S. Stratton, Director.

Properties of Engineering Materials A3-20 Electric Welding of Metal. A comparison of tensile tests on welded metal plates shows that the mechanical properties of the material produced at the Bureau of Standards are uniformly lower than those of the Wirt-Jones test conducted by the Welding Research Sub-Committee. The personal element appears to be an appreciable factor in welding. Microscopic examination and hardness tests do not show any well-defined relation between physical properties and microstructure because of premature failure due to flaws. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Rubber and Allied Substances A1-20 Gutta Percha. Weston A. Price, M.S., D.D.S., of Research Institute of the National Dental Association, in a report of laboratory investigations on tooth-filling materials discusses the expansion of gutta percha with temperature change and also the action of the evaporation of solvents on gutta percha. He gives a report of Dr. Dayton C. Miller of Case School of Applied Science. On heating and cooling a sheet of pink gutta percha the sheet contracted greatly in the direction which appeared to be that in which it was rolled, while expansion took place in the direction perpendicular to this. In heating from 22 deg. fahr. to 211 deg. fahr. the contraction of area was 14.7 per cent. A second piece 70 mm. by 70 mm. was heated from 70 deg. fahr. to 211 deg. fahr., changing in area to 63.0 mm. by 72.5 mm. The thickness increased from 0.843 mm. to 0.912 mm. This means a diminution of length of 10 per cent, an increase of breadth of 3 per cent and an increase of volume of about 1 per cent. The test under a rising and falling temperature showed a variation in the form of a hysteresis curve. On annealing in boiling water for 10 min. somewhat similar results were obtained.

Chloroform was found to absorb gutta percha. When the solvent was allowed to evaporate the volume of a thick solution just firm enough to hold its shape was 260 per cent of the volume when all of the solvent was driven off. Address Dr. Weston A. Price, Research Institute of National Dental Association, Cleveland, O.

Wood Products A1-20 Laminated-Wood Forms. Solid artificial limbs are difficult to obtain without checking. Built-up limb blanks have been proposed, made with water-resistant casein glue. Little or no waste is experienced in this way.

After 175 games, laminated maple bowling pins were returned for photographing. They were in excellent condition, but one gave way in a casein glue joint. This is not considered a defective pin, as solid pins often split. Hide glue and casein glue have stood up equally well. Birch pins are not so satisfactory. Two sets of maple pins are being made up to be combined with two sets of standard pins. Laminated gun stocks of black walnut are to be shipped to the Ordnance Department. Laminated shoe lasts are being tried by the Badger State Shoe Company. Forest Products Laboratory, Madison, Wis. Address Director.

Wood Products A2-20 Drying Schedule for Air-Seasoned Oak. Table 3 which follows for 4-in. by 4-in. plain-sawed oak with 15 per cent moisture content gives the same result as would be reached by 9 to 12 months of air seasoning.

After stock is dry, kiln is held at 145 deg. fahr. with 80 per cent humidity for 10 hours to balance moisture content and prevent warping.

Wood Products A3-20 Wood Preservatives. The Forest Products Laboratory has treated sap-pine ties and red-oak ties with sodium fluoride, zinc chloride and creosote. The sodium fluoride has high toxicity, is not injurious to metal and is convenient to handle. Sap-pine ties were placed in the mines at Birmingham, Ala., in 1914, while red-oak ties were placed on the tracks of the Baltimore and Ohio railroad. After five years of mine service the ties treated with sodium fluoride were found in as good condition as those treated with zinc chloride. Both showed little deterioration. The creosoted ties were in better condition while untreated ties were in advanced stages of decay. The railroad

ties which were treated were practically all sound, while untreated ties had to be removed. Forest Products Laboratory, Madison, Wis. Address Director.

TABLE 3

Stage of Kiln run in hours.	Temperature, deg. fahr.	Humidity, per cent.
1	120	100
6	120	100
12	125	85
24	125	80
36	130	70
48	130	60
60	135	60
72	135	60
84	140	60
96	140	50
108	140	50
120	140	40
144	140	40
156	145	35
168	145	35
180	145	30
192	145	25
Until dry	145	25

Wood Products A3-20 Wood Pulp with Decay. Wood pulp infected with molds and fungi has been shown to be defective in producing dirty paper, in requiring extra sizing, in sticking to couch and press rolls, and gives trouble from excessive foaming. Infected pulp is free in its action and causes difficulty in carrying the necessary amount of water. Infected pulp yields 10 per cent less finished paper than clean pulp, in addition to reducing strength of the finished paper. Forest Products Laboratory, Madison, Wis. Address Director.

Wood Products A4-20 Shrinkage of Veneer. The veneers made from steam logs or boiled logs were tested and found to contain about the same amount of moisture before drying (65 per cent) and about the same amount after drying (10 per cent). The shrinkage of each kind was about the same, variation being no greater than that found in the pieces from the same treatment. Forest Products Laboratory, Madison, Wis. Address Director.

Wood Products A5-20 Moisture Content of Wood. Moisture content of wood has been found to be independent of the density of the wood. With a relative humidity of 38 per cent at 80 deg. fahr. in the oven the moisture content is about 11 per cent and with 88 per cent relative humidity the moisture content is 18.8 per cent. This is the same for specimens of varying densities. Forest Products Laboratory, Madison, Wis. Address Director.

B—Research in Progress

The purpose of this section of engineering research is to bring together those who are working on the same problem for cooperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Aircraft B2-20 Wind Tunnels and Propellers. The National Advisory Committee for Aeronautics reports a research in progress by means of models to determine the best form of wind tunnel and the best type of propeller to use in drawing the wind stream through the tunnel. Various arrangements are being studied, especially with regard to their power consumption for a given wind speed and to the steadiness of velocity and direction of air currents. Address Joseph S. Ames, of the Executive Committee of the National Advisory Committee for Aeronautics, 4th St. and Missouri Ave., N. W., Washington, D. C.

Cement and Other Building Materials B1-20 Compressive Strength of Concrete. A paper is being prepared on the compressive strength of concrete based on the results of tests made by the Bureau of Standards at Lehigh University and Lafayette College in 1918 and at the Structural Materials Laboratory at St. Louis from 1904 to 1910. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Internal-Combustion Motors B2-20 Ignition Apparatus. The Bureau of Standards has been developing a mathematical theory of the building-up of voltage in the secondary winding after the opening of the primary breaker. Data from nine magnetos have been received by the laboratory. The ratio of transformation and coupling coefficient has been determined and measurements of the mutual inductance are now in progress. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Materials of Engineering B1-20 Thermal Expansion. A research in the determination of the thermal expansion for various substances. Several proposed outlines for the work have been drawn up. The work will keep the present laboratory force devoted to this subject busy for six months. Address Bureau of Standards, Washington, D. C. Address Director.

Metallurgy and Metallography B3-20 Hardness Relations. Relation of hardness, temperature of pouring and machining properties of cast iron of given thickness and composition. Address Prof. W. W. Bird, Worcester Polytechnic Institute, Worcester, Mass.

Properties of Engineering Materials B6-20 Strain-Gage Test. A strain-gage test of the 350-ton fitting crane at the Philadelphia Navy Yard has just been made. The results of this test are to be made up in the form of a report. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Properties of Engineering Materials B7-20 The Use of the Camera in Studying Physical Properties. The Bureau of Standards has been investigating photographic methods of studying elongations and lateral deformation of steel during tensile tests to determine the relation between elongation and lateral deformation. It is also developing a special camera for taking panoramic photographs of the interior of a gun barrel to study the effects of erosion. The lenses have been perfected and the camera is being constructed. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Properties of Engineering Materials B8-20 Insulating Materials. The Bureau of Standards has carried on extensive investigations of the electrical and mechanical properties of insulating materials, giving particular attention to their behavior at radio frequencies. The research will include the effects of moisture and other tests to determine the practical usefulness of various materials. Special study has been made of bakelite and other materials of the phenol-methylene type, and materials such as glass, mica, celluloid, electrosote, paraffin, fiber, hard rubber, porcelain and wood will be included. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Properties of Engineering Materials B9-20 Physical Constants of Materials Used in Refrigeration. The Bureau of Standards is investigating the physical properties of constants of materials used in refrigeration. The Bureau has recently determined the vapor pressure of saturated ammonia and densities of the liquid and saturated vapor. It has also determined the specific heats of sodium-chloride solutions. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Protective Devices B1-20 Carbon Monoxide Detector. A. C. Fieldner, Supervising Chemist, G. St. J. Perrott, Physical Chemist, Bureau of Mines Station, Pittsburgh, Pa. So far the detector developed for gas-mask use by Lieutenant-Colonel Lamb and Captain Larson of the Chemical Warfare Service seems to be most promising. Bureau of Mines, Address Van H. Manning, Director, Washington, D. C.

Railroad Rolling Stock and Accessories B1-20 Chilled-Iron Car Wheels. Experiments are being made at the Bureau of Standards to determine temperatures at various portions of a wheel heated on the rim and to study the effects of this heating. Several wheels have already been tested at this plant. Work of a similar nature is being carried out at the University of Illinois. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

C—Research Problems

The purpose of this section of Engineering Research is to bring together persons who desire coöperation in research work or to bring together those who have problems and no equipment with those who are equipped to carry on research. It is hoped that those desiring coöperation or aid will state problems for publication in this section.

Textile Manufacture and Clothing C1-20 Drying of Thin Gauze on Tentering Machines. The effect of humidity; the effect of velocity of air; the effect of heating cloth by radiation or by convection; the effect of drying selvages by installing steam pipes close to tenter fingers; best relative humidity of air at discharge for maximum drying rate. Address D. M. Ferris, Graduate Student, M.I.T., 37 Lee St., Cambridge, Mass.

D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work may be done.

Harvard University D1-20 Cyrogenic Laboratory. The equipment for the liquefaction of gases and for very low-temperature work includes two commercial air compressors for pressures to 3000 per sq. in., and two commercial types of liquefiers as well as special apparatus which is under construction. In the Refrigerating Laboratory ammonia and carbon-dioxide compression plants are about completed.

The Internal-Combustion Laboratory is being equipped, although much of the apparatus for this laboratory has not been

purchased. Address Prof. Lionel S. Marks, Harvard University, Cambridge, Mass.

Machine Tools D1-20 Cutting Action of Machine Tools. The University of Cincinnati is equipping its mechanical laboratory for the purpose of making investigations on the cutting action of machine tools. The university has recently received an Olsen efficiency-testing machine for files, milling cutters, lathe tools, hack saws and drills, and has also bought a number of Government machine tools to be used on research work. One of them is a large heavy-duty radial drill. A No. 3 planer milling machine will also be used for research work. The laboratory is to have a Charpy impact-testing machine and Olsen impact-testing machine and four Farmer fatigue-testing machines. Address Prof. A. L. Jenkins, University of Cincinnati, Cincinnati, Ohio.

University of Cincinnati D2-20 Thermal Laboratory. The Mechanical Engineering Laboratory of the University of Cincinnati is equipped with an experimental gas engine made by the Foos Gas Engine Company, four small gas and oil engines, a 12 by 24-in. Hamilton Corliss engine, a Fairbanks gas producer and a number of automobile engines. Address Prof. A. L. Jenkins, University of Cincinnati, Cincinnati, Ohio.

E—Research Personnel

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

Purdue University E1-20 The Experiment Station at Purdue University is about to issue a bulletin on the use of electric power in small pumping stations, by Professor Ewing, and a bulletin on the Coefficient of Discharge of Sewage Sprinkler Nozzles, by Prof. W. W. Greve. Prof. O. C. Berry has nearly completed a bulletin on the Investigations of Carburetors and Prof. R. V. Achatz has completed a circular on the Effect of Preservative Treatment of Various Kinds of Telephone and Telegraph Poles. Address Purdue University, Lafayette, Ind. Dean C. H. Benjamin, Director.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession and especially the members of the A. S. M. E. of bibliographies which have been prepared. These bibliographies have been prepared at the request of members, and where the bibliography is not extensive, this is done at the expense of the Society. For bibliographies of a general nature the Society is prepared to make extensive bibliographies at the expense of the Society on the approval of the Research Committee. After these bibliographies are prepared they are loaned to the person requesting them for a period of one month. Additional copies are prepared which are available for periods of two weeks to members of the A. S. M. E. or to others recommended by members of the A. S. M. E. These bibliographies are on file in the offices of the Society and are to be loaned on request. The bibliographies are prepared by the staff of the Library of the United Engineering Society which is probably the largest Engineering Library in this country.

Economics F1-20 Valuation of Street Railway Systems. A bibliography of 1½ pages. Search 2835. Address A.S.M.E., 29 West 39th St., New York.

Hydraulics F1-20 Flow of Oil in Conduits. A bibliography of 10 pages. Search 2825. Address A.S.M.E., 29 West 39th St., New York.

Metallurgy and Metallography F1-20 Microstructure of Electric and Acetylene Welds. A bibliography of 1½ pages. Search 2784. Address A.S.M.E., 29 West 39th St., New York.

Petroleum, Asphalt and Wood Products F1-20 Flow of Oil in Conduits. A bibliography of 10 pages. Search 2825. Address A.S.M.E., 29 West 39th St., New York.

Wood Products F1-20 Marine Borers. A bibliography prepared by the Forest Products Laboratory, U. S. Forest Service, Madison, Wis. This contains eight references to articles and treatises. Forest Products Laboratory. Address Director Forest Products Laboratory, Madison, Wis.

Unemployment, National Taxation and Profit Sharing

Reconciliation of the Needs and Demands of the Government, the Public, the Employer, and the Worker

By HENRY HESS,[1] PHILADELPHIA, PA.

THE present disturbance in our industrial position has been a long time in the brewing. This process may be likened to a period of slow boiling under a gentle heat that gave the cook no serious cause for alarm, even though it did occasionally tilt the cover of the pot.

But let us leave this simile to concern ourselves with basic causes and see whether their recognition may not lead us to a basic remedy. It will be necessary to go back to the beginning of the modern industrial era and note the change which that brought about.

Under the older feudal system the subsistence of the working element was more or less well taken care of by the overlords or by the masters in the various guilds; and as long as these overlords and masters fulfilled their obligations, matters went along smoothly. It was only when these obligations were forgotten and the duty of providing subsistence was omitted that matters became serious. In other words, when subsistence became endangered the social economy became endangered.

When such subsistence becomes endangered under our changed conditions, then our modern social economy is in danger of similarly breaking down.

There are many changes in the relative situation of the modern worker as compared with his brother of bygone ages, but the basic interest is the same; the worker must be assured of his subsistence and of a subsistence of the improved character that the advance of general civilization and culture has brought about. This is our problem today under our modern industrial system, as it has been the problem under the feudal system that has been displaced, and as it will be the problem under whatever future system may take the place of that of today, and so on to the end of time.

Now what one basic trouble stands out above all others? There are many minor ones that look large at the moment and large in the eyes of many; but which one applies to every man, woman and child worker? Unquestionably the fear that the means of subsistence may be withdrawn at any moment, which fear is the fear of unemployment. When we analyze the demand for increased wages we find that it resolves itself into the hope that the difference between increased and existing wages will permit the accumulation of a fund the interest of which will provide the basis for defraying the living cost during the recurring periods of unemployment.

The writer proposes to address himself to this problem, as he considers it the real problem, though frequently not definitely recognized as such; and to those others that are coexistent with it, such as the provision of the means for the maintenance of a proper government and all that that implies in activities that are best delegated to government. This then becomes the problem for our industrial system, since it is this which earns and creates wealth and then distributes it.

Men band themselves together in business organizations, which have gradually taken on the preferred corporate form; here capital and labor coöperate to increase the national wealth and to distribute it and to minimize the risks involved.

There are two groups in such corporations; one is generally

[1] 308 Bailey Building Past Vice-President Am.Soc.M.E.

Discussion prepared for the Industrial Relations Sessions at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, December 1919.

referred to as capital, the other as labor. The ideal grouping will equally divide the risks and responsibilities; and given such ideal grouping, the results or profits should be equally divided. Labor is today striving for such equal division, but is not yet willing to share equally the risk and responsibility. The more enlightened section of capital is willing to share with labor in proportion as labor fits itself to and does assume its share of the burden.

When that condition has been reached there will no longer be any problem that is basically serious; both sides will by then have forgotten such matters as unionism, the open shop, the closed shop, collective bargaining and whatever other standard people assemble under to wage industrial war and to inflict on one another the utmost injury of which they are capable; instead, they will mutually coöperate for mutually equal benefit.

Until that ultimate goal is reached man must live and live with

HYPOTHETICAL NATIONAL BALANCE SHEET[1]

Common Capital		$50,000,000,000
Preferred Capital		10,000,000,000
Borrowed Capital (corresponds to Bonds; to receive 5% interest and be retired in 20 yr.)		30,000,000,000
Wages and salaries of 12,800,000 employees (exclusive of firm members), $1060 per capita		13,568,000,000
Unemployment cost at 8% (approx.)		1,085,000,000
Gross income for 1917 (made up of Wages, Taxes, Interest, Dividends and Surplus for Manufacturing, Mining, Railroad and Public Utilities), $1,926 per capita		$24,653,000,000
Wages at $1060 per capita	$13,568,000,000	
Bonded Indebtedness at 5%	1,000,000,000	
Retirement of borrowings per yr.	1,000,000,000	
Depreciation	500,000,000	
State and Local Taxes, 2/3 of 1917	1,000,000,000	17,068,000,000
Balance Net Earnings before Federal Tax		$7,585,000,000
1st Charge—Income Tax (1917)		405,360,000
Balance		$7,179,640,000
2d Charge—Cumulative Preferred Stock 6%		600,000,000[2]
Balance		$6,579,640,000
3d Charge—Plant betterment (=twice depreciation)		1,000,000,000
Balance		$5,579,640,000
4th Charge—Profit Share 2% of Wage Bill[2]		271,360,000
Balance		$5,308,280,000
5th Charge—Corporations' share to unemployment		813,640,000[2]
Balance		$4,494,640,000
6th Charge—Stockholders' Common share 4% dividend	$2,000,000,000	
½ as profit share	1,000,000,000	3,000,000,000
Balance		$1,494,640,000
7th Charge—Excess Profits (2/3 of 1917 charge)		650,000,000
Corporations' Surplus Balance is 1.69%		$844,640,000

[1] Based on year 1917.
[2] To be applied to labor's share to unemployment.
[3] Annual fixed charge if industry is shut down.

reasonable decency and must adequately subsist during those periodic disturbances in the orderly process of increasing individual and national wealth.

So far there are probably very few but agree with these general statements; but how carry them into effect? They have been and are being carried out here and there by small bodies and with entire success and consequent satisfaction to both sides.

If these few concerns gather followers in sufficient number to comprise the many that make up the nation, then the sporadic few would have become the complete whole. The balance sheets that are made up by the many individual concerns could then be gathered into one national balance sheet.

The writer has prepared such a hypothetical balance sheet as well as the insufficient data available permit. Unfortunately the Government has not included collection of data covering unemployment in its census. Reliance must therefore be placed on such fragmentary information as has been collected by other agencies over certain sections of the country.

Unemployment is probably larger the denser the industrial population. Therefore, applying the conditions of New York City to the entire country will probably give a result that is in the nature of an overstatement and is in consequence safe for the liberation of funds to cover this unemployment cost.

A very careful census for New York City is available and published by the U. S. Department of Labor, Bureau of Labor Statistics in its Bulletin No. 172 in April 1915.

Averaging a table on page 10 of that bulletin shows that of all male and female workers 60 per cent were unemployed for 65 days, which corresponds to an average constant unemployment of 10.5 per cent.

The Federal Government had found it necessary to gather reliable data in connection with the collection of taxes. A brochure published by Prof. David Friday and entitled Profits, Wages and Industrial Progress, has furnished much information useful in the set-up of the hypothetical balance sheet prepared by the writer.

An examination of that sheet will show that all of the usual features carried in a condensed balance sheet are provided for, such as taxes of various kinds, plant depreciation and plant betterment that keep the industry in productive health, interest and repayment of borrowed capital, dividends on preferred capital with a sufficient surplus to return this preferred capital, ordinary dividends and such new features as provision for unemployment and profit sharing of capital and labor.

It is believed that these figures are entirely conservative, since the 1917 actual surplus was $256.25 per capita or $3,280,000,000, which is nearly four times the amount the above hypothetical balance sheet leaves as surplus. Ten per cent unemployment is equivalent to 9 years' surplus accumulation or (9 x $844,600,000 =) $7,601,400,000. Deducting from this the cost of one year's shutdown, $1,413,640,000, leaves a balance of $6,187,760,000, which corresponds to a dividend on common capital for 10 years of 12.37 per cent or per year of 1.24 per cent, this equity increasing the annual normal common capital dividend to 5.24 per cent.

RÉSUMÉ

The proposal suggests the removal of a very potent cause of labor unrest by insuring labor against the economic loss of involuntary unemployment through the accumulation of a fund. This fund is contributed to by labor, which applies a portion of its participation in general profits.

The Government's need for funds, over and above the amount raised by income tax, is covered by lending to the Government this unemployment fund.

It is possible to analyze or to set up a balance sheet showing the tangible quantities of the nation's business, but that method cannot be applied to the more intangible factors that are nevertheless the more important ones. Avoidance of the many consequences of unemployment and the fear of that will relieve the community of a very heavy burden and tend to an increased output of work willingly rendered by the worker, who is not only relieved of this fear of unemployment, but is also assured of a fair participation of the resulting profits.

The employer or capitalist finds his reckoning in the general stabilization of his business, which stabilization is of the same character as the assurance against unemployment.

The general public finds its interest given in the stabilization of business conditions generally and in the relief from the burdens of various kinds, financial and social, which it must carry as the result of unemployment.

The Government finds its advantage in there being placed at its disposition, for a period of years, an amount which it will therefore not have to raise by taxation, and this again will ease its public relations, as tax gathering is probably the most-objected-to feature of government.

Work of the Boiler Code Committee

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 267-272, inclusive, as formulated at the meeting of January 7, 1920, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE NO. 267

Inquiry: *a* Is it not permissible to form door openings in the furnaces of locomotive type boilers with the overlapping flanges riveted so that the heads of rivets project into the door opening? Is it advisable that these flanges be welded instead of riveted?

b Is there any objection under the rules of the Boiler Code to the use of baffles over the feed pipe discharge into the side of the barrel of locomotive type boilers?

Reply: *a* The projection of rivet heads into the door opening is not prohibited by the Boiler Code, although it is the recommendation of the Committee that in case the flanges are riveted the heads in the door opening be countersunk. Welding of the flanges is permissible under the rules of the Boiler Code, but there is nothing in the Boiler Code that indicates preference for either riveting or welding.

b Inasmuch as the use of the internal feed pipe is required only for h.r.t. boilers, there is no objection to the use of a feed-water baffle over the discharge of the feed pipe. It is, however, essential that the feed water shall not be discharged into the boiler, close to the riveted joints in the shell or to furnace sheets. (See Par. 316).

CASE NO. 268

Inquiry: Inasmuch as the discharge of feed water into vertical fire tube boilers, in accordance with the requirement of Par. 316 of the Boiler Code, has caused serious difficulties from leaky tubes in the lower tube sheet, is it permissible to protect the feed water discharge through a feed water pocket riveted within the shell at a point above the water leg with handhole opening for cleaning.

Reply: It is the opinion of the Committee that such a method of delivery of feed water to the boiler is in full accord with the requirements of the Boiler Code.

CASE NO. 269

Inquiry: If, under the provision made in Par. 212c of the Boiler Code, advantage is taken of the opportunity to increase the pitch of the staying for a cylindrical furnace, is it to be assumed that a portion of the increased load on the staybolt is to be supported by the resistance of the outer cylindrical shell to collapse, or must the staybolt be designed to carry the full load upon the stayed area of the furnace sheet?

Reply: It is the opinion of the Committee that the special provision made in Par. 212c for increased pitch, does not contemplate the division of the stress upon the stays, in view of the supporting power of the outer cylindrical shell; it will not be permissible to increase the pitch under this rule, beyond the ability of the stays selected to carry the load.

CASE NO. 270

(In the hands of the Committee)

CASE NO. 271

Inquiry: Is it allowable under Par. 268 to utilize a flanged collar pressed into and flanged over the edges of the shell for a pipe connection, instead of riveting a flange to the shell, when the thickness of the plate is not sufficient to give the required number of threads?

Reply: It is the opinion of the Committee that such construction of pressed and flanged reinforcement for an opening in the shell, will be allowable under the requirement of Par. 268, for any pipe opening not exceeding 3 in. pipe size, provided the threaded portion complies with Par. 266 of the Code.

CASE NO. 272

Inquiry: Is it permissible to form a dry pipe in a h.r.t. boiler by insertion of a 6 in. pipe threaded through a flange riveted to the rear head?

Reply: It is the opinion of the Committee that this connection of dry pipe is allowable provided: (1) That a flanged nozzle riveted to the head to receive a flanged fitting is employed; (2) That the dry pipe is detachably connected to the nozzle; (3) That the dry pipe is properly supported.

CODE FOR BOILERS OF LOCOMOTIVES

In the August 1919 issue of MECHANICAL ENGINEERING (page 682) there was published the preliminary report of the Sub-committee of the Boiler Code Committee on Boilers of Locomotives, which is proposed as Part I, Section III of the Code. This report was the result of over two years careful investigation and study by this Sub-committee and the report was first submitted to the membership of the Society at the spring meeting at Detroit, Michigan, in June 1919. The report was accepted by the meeting and ordered published. Following the publication in August 1919, arrangements were made in accordance with the established practice of the Boiler Code Committee, for a public hearing on this question, which was held during the business session of the Annual Meeting on December 3rd, 1919, in order that all interested parties might be given an opportunity to discuss any feature of the requirements in the proposed Code.

As a result of the hearing and the discussion, which lasted into the following day, December 4th, recommendations were accepted from the hearing, which resulted in the following revisions in the preliminary report. They are here published for the information of the membership. Anyone desiring to discuss the changes here proposed is requested to address the Secretary of the Boiler Code Committee, 29 West Thirty-ninth St., New York, N. Y.

Revisions of Preliminary Report on Boilers of Locomotives

Not Subject to Federal Inspection or Control

Based on Report as published in MECHANICAL ENGINEERING (Journal of the American Society of Mechanical Engineers), August, 1919, page 682.

PAR. L-2

CHANGE WORDS IN SECOND LINE AS FOLLOWS:

excepting from tube sheets — to read — excepting front tube sheets.

PAR. L-18:

CHANGE HEADING OF TABLE 2 TO READ AS FOLLOWS:

Gage thickness of walls of fire tubes

PAR. L-20:

CHANGE PARAGRAPH TO READ AS FOLLOWS:

The maximum allowable working pressure is determined by employing the factors of safety, stresses and dimensions designated in these rules.

The factor of safety used in design and construction of new boilers shall not be less than 4.5.

The factor of safety used in determining the maximum allowable working pressure calculated on the conditions actually obtaining in service shall not be less than 4.0.

The maximum allowable working pressure determined by conditions obtaining in service shall not exceed that for which the boiler was designated.

No boiler shall be operated at a higher pressure than the maximum allowable working pressure, except when the safety valve or valves are blowing, at which time the maximum allowable working pressure shall not be exceeded by more than 5 per cent.

PAR. L-21:

ELIMINATE LAST SENTENCE, WHICH READS AS FOLLOWS:

For new constructions covered in Part III, FS in the above formula = 4.

PAR. L-27.

ELIMINATE ENTIRE PARAGRAPH.

PAR. L-28.

RENUMBER THIS AS PAR. L-27.

PAR. L-29:

RENUMBER THIS AS PAR. L-28.

PAR. L-29:

INSERT NEW PARAGRAPH AS FOLLOWS:

Autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the Code and when the safety of the structure is not dependent upon the strength of the weld.

PAR. L-30:

REVISE LAST SECTION OF PARAGRAPH TO READ AS FOLLOWS:

When boiler shells are cut to apply steam domes or manholes, the net area of metal, after rivet holes are deducted, in flange and liner, if used, must be not less than the area required by these rules for a length of boiler shell equal to the length removed. A height of vertical flange equal to three times the thickness of the flange shall be included in the area of the flange.

PAR. L-31

CORRECT FORMULA TO READ AS FOLLOWS:

$$P = C \times \frac{I^2}{t^2}$$

PAR. L-32:

CHANGE FIRST LINE OF SECOND SECTION TO READ AS FOLLOWS:

Staybolts behind permanent brickwork, frame braces, or grate bearers.

PAR. L-52:

ADD NEW SECTION TO THIS PARAGRAPH TO READ AS FOLLOWS:

The ends of arch tubes must be belled out to a diameter ¼ in. larger than the hole in the sheet to which they are connected.

PAR. L-58:

ADD NEW SECTION TO THIS PARAGRAPH TO READ AS FOLLOWS:

If, in any longitudinal section of an unstayed plate, more than two holes are so located that the strength of the ligament between them is reduced below the strength of ligament of the longitudinal seam, the plate must be reinforced to maintain the strength through that section.

PAR. L-60:

CHANGE LAST SENTENCE TO READ AS FOLLOWS:

than five per cent. above the specified boiler pressure.

PAR. L-73:

CHANGE FIRST LINE TO READ AS FOLLOWS:

Each boiler shall have at least one water glass provided with top and bottom shut-off cocks, and lamp

ALSO ADD NEW SECTION TO READ AS FOLLOWS:

Tubular water glasses must be equipped with a protecting shield.

PAR. L-75:

CHANGE LAST WORD TO READ "ENGINEMEN."

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of MECHANICAL ENGINEERING by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in this journal, or brief articles of current interest to mechanical engineers.

The Value of Sheet Asbestos on Hot Pipes

Comments on Contribution in January Number

TO THE EDITOR:

In notes on research entitled Value of Sheet Asbestos on Hot Pipes, by Mr. T. S. Taylor, published in a prominent place in the January issue of MECHANICAL ENGINEERING, certain statements were made which, while entirely true in themselves, have been subject to considerable misconception.

There is nothing new or remarkable in the fact that a bright galvanized-iron surface will radiate heat at a much slower rate than a dull mat surface. Therefore, it is not surprising that placing over the bright surface a *very thin* layer of asbestos paper should increase the radiation. The paper was only a little over 1/100 in. thick, which is so thin that it could have but little insulating value, and the net effect was mainly the change in the character of the radiating surface and consequently the rate of radiation.

It should be borne in mind, however, that the high surface resistance to heat flow presented by a bright surface decreases rapidly as the surface becomes tarnished or if it is painted. Therefore, the radiation from such surfaces becomes much greater.

The principal cause for mistaking the true significance of the statements was the failure on the part of the average reader to distinguish between mere asbestos paper and asbestos insulation. This distinction was not mentioned in the article and it has been but natural that the casual reader should attribute to asbestos in general the poor results shown by the test for very thin asbestos paper.

The contribution is an arraignment and rightly so of the practice of covering furnace pipes with a thin layer of asbestos paper. The belief has been too prevalent that pipes covered with "asbestos" were properly protected, regardless of the thickness or quality of the asbestos. Therefore, instead of indicating any lack of usefulness of asbestos, the results of these tests properly interpreted bring out more forcibly the need for sufficient thickness of proper insulation.

New York, N. Y. L. B. McMILLAN.

TO THE EDITOR:

I read with some concern an article in the January number of MECHANICAL ENGINEERING, page 69, on the value of sheet asbestos on heat pipes. This fact was reported in a paper read by the writer at the June 1919 meeting of the National Warm Air Heating and Ventilating Association, and has since been given wide publicity. I am therefore surprised to see this article appear.

It is interesting to note that the results obtained by this investigator agree very closely with the results reported by the writer in the proceedings of the meeting mentioned above. His work certainly serves to clinch our argument against the use of asbestos-paper covering on heat pipes.

I am sending under separate cover a copy of a paper by Prof. A. C. Willard, of the University of Illinois, Mem.Am.Soc.M.E., dealing with our testing program for warm-air furnaces. It contains some data on our tests of insulating materials for heat pipes, and the other information contained may be of interest to you.

Urbana, Ill. V. S. DAY, Research Assistant, University of Illinois.

In the report referred to by Professor Willard results are given of measurements made by Mr. Day of the temperatures across the air currents in a tin leader running from a hot-air furnace. Temperature traverses were made in a 10-in. leader of bright tin and in the same leader covered with one layer of asbestos paper weighing 10 lb. to the 100 sq. ft. These tests showed that the asbestos-paper-covered pipe lost heat more rapidly than the bright tin pipe, a fact which led to subsequent experiments on the heat lost from covered and uncovered pipe.

TABLE 1 RELATIVE HEAT LOSSES FROM THIN SHEET METAL PIPES WHEN COVERED AND UNCOVERED

Description of Drum	Wt. Steam Condensed in 10 hr.	Coef. of Emissivity
1 Bright I C tin, 1 leader section	11.63	1.40
2 Same as No. 1, but covered with one sheet 10 lb. asbestos paper	17.80	2.30
3 Same as No. 2, but painted with gray enamel	18.14	2.32
4 Same as No. 1, but painted with gray enamel, as in case No. 3	18.88	2.40
5 Black iron, No. 28 U. S. gage	18.29	2.25
6 Galvanized iron No. 28 gage	11.72	1.55
7 Same as No. 1, but covered with 3-ply air-cell asbestos paper	5.86	0.70
8 Same as No. 1, with 5/16-in air space made by double wall of tin	6.32	0.78

For this purpose a special heat-transmission plant was built, supplied with low-pressure steam. Sheet-metal drums, all of the same size, were used in determining the heat loss. Five drums were tested at one time, with a sixth drum operated as a control in order to maintain uniform conditions. A few of the more interesting results are given in Table 1. In this table the "coefficient of emissivity" is based on the temperature difference, steam to air (steam pressure maintained at 1½ in. of mercury), and gives the loss in B.t.u. per sq. ft. of surface per hr. per deg. fahr., temperature difference.

As in the case of the tests by Mr. Taylor referred to in Mr. Day's letter, there was a large increase in heat loss when the metal was covered with a single thickness of asbestos paper without air space to retard the transmission of heat. Superior results were obtained, however, with air-cell asbestos paper and with a leader having a double wall and air space between, as shown in Tests Nos. 7 and 8 in Table 1.—[EDITOR.]

TO THE EDITOR:

It has been brought to the writer's attention that some readers of his notes on the above subject, contributed to the January issue of this magazine, have obtained very incorrect ideas concerning the proper interpretation of the results there given. Numerous letters relating to this contribution have been received, but so far no one has given incorrect impressions of the results. The writer has learned indirectly, however, that some readers have interpreted the results to mean that since a little asbestos is a poor thing on hot-air pipes, more asbestos would be even worse. It is a little difficult to see how any one in reading the notes can come to such conclusions. While it is specified clearly that a thin layer of asbestos on hot-air pipes promotes the loss of heat to the extent of 33 per cent more than if the pipe was left bare, it is also made clear that three layers of thin asbestos 0.013 in. thick applied loosely will make the loss from the covered pipe the same as from the bare pipe; and furthermore it is pointed out that if the layer of asbestos is sufficiently thick, about ⅛ in., the loss through the covered pipe will be only 75 per cent of that through the bare pipe, thus resulting in a saving of 25 per cent. A thicker layer will cause even a less loss. This statement cannot be taken to hold indefinitely for various sizes of pipes, but it does hold within limits for pipes of such dimensions as 9 in. to 10 in. in diameter.

The reason why more heat will pass through a pipe when covered tightly with thin asbestos than when bare is that the effective area of the pipe as far as molecular dimensions and motions are concerned, is increased at least some two or three times by the layer of asbestos, while the thermal resistance due to the layer of asbestos is quite small. The result is that more molecules can come into close contact with the surface, and thus having their kinetic energy or temperature increased, more heat will be carried away. This increases the loss due to conduction and in particular that due to convection, which is the principal method by means of which heat is liberated at the temperatures here dealt with. The extra loss is thus due to the increase in molecular contacts and not to the difference in the radiating power of the two surfaces. Radiation at the temperature differences dealt with in furnace-pipe surfaces plays a very insignificant part in the loss of heat.

Now, since the effective molecular area of the surface of the pipe is so much increased by the asbestos surface over that of the smooth pipe, it is necessary to add enough asbestos or heat-insulating material to cause a temperature drop through this insulation so as to have its external surface at a considerably lower temperature and thus reduce the loss from the outer surface. Thus, if the layer is sufficiently thick the temperature of its outer surface will be low enough to overcome the advantage gained, as far as heat loss is concerned, by the rough surface. Consequently, in order to protect pipes, meet fire-insurance regulations, and also save loss of heat, hot-air pipes should have a much thicker coating of insulating material than is at present applied. This can be a thicker layer of asbestos, several layers of thin sheet asbestos, asbestos air-cell paper or any suitable material used for this purpose.

Pittsburgh, Pa. T. S. TAYLOR.

The Correct Statement of Averages

TO THE EDITOR:

While agreeing with Mr. Hess that an arithmetical average is very apt to be misleading (page 955, December MECHANICAL ENGINEERING), I do not feel sure that the mere statement of maximum and minimum figures is sufficient indication of the degree of reliability achieved.

Personally, I have found my own graphical method, which was described on page 226, vol. 104 of *Engineering*, the most reliable one I know, since it eliminates data which are obviously out of accord with those most often obtained in a series of experiments.

London, England. C. H. WINGFIELD, M. Inst. Mech. E.

The Swiss Economic Mission expects to sail on May 7, 1920, for a forty-two days tour of this country to study the general economic conditions. A delegation of about sixty engineers from the Mission will probably be in St. Louis at the time of the Spring Meeting.

MECHANICAL ENGINEERING

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

Spring Meeting of Mechanical Engineers at St. Louis

The attention of mechanical engineers is called to the Spring Meeting of The American Society of Mechanical Engineers to be held at St. Louis May 24 to 27. Two of the leading sessions will be devoted to subjects of local interest, although of national importance, those of the development of transportation on the Mississippi River, with a view to shipping products to foreign countries by water by the lower Mississippi and the Gulf of Mexico, and the other on recent developments in industrial housing in which there is a large project under way at St. Louis.

There will be papers on fuels, oil engines, measurement of the flow of water, transmission of heat, pumping engine tests, airplane design, supercharges for aeroplane engines and performance of automobile trucks, etc. All authors who expect to contribute papers are asked by the Committee on Meetings and Program to send their manuscripts to the Society by March 15. It is expected that the program of the meeting will be published in the April number of MECHANICAL ENGINEERING.

A.S.M.E. Members in Second Pan American Financial Conference

That engineers are steadily coming to the front in the discussion of national and international problems was once again evidenced by the number of A. S. M. E. members who participated in the deliberations of the Second Pan American Financial Conference, which was in session in Washington for 10 days beginning on January 19. The Conference was attended by ministers of finance and other delegates from each of twenty Latin-American countries and representatives of the United States appointed by the Secretary of the Treasury. Among the leading Americans chosen were the following members of The American Society of Mechanical Engineers: Arthur L. Church, for Bolivia; Maurice Coster, for Columbia; Andrew Fletcher, for Chile; Hollis Godfrey, for Peru; John Hays Hammond, for Chile; George H. Harries, for Salvador; E. M. Herr, for Ecuador; Ira N. Hollis, for Argentina; George L. Hoxie, for Panama; Chester B. Lord, for Dominican Republic; Charles T. Plunkett, for Dominican Republic; Calvin W. Rice, for Bolivia; W. L. Saunders, for Nicaragua; T. Stebbins, for Haiti; George F. Swain, for Panama; F. H. Taylor, for Uruguay; G. R. Tuska, for Mexico.

"Industrial Unrest" Not an A.S.M.E. Pamphlet

With other members of the Society, the signers of this statement have received an anonymously written and distributed pamphlet entitled "Industrial Unrest," bearing the seal of The American Society of Mechanical Engineers and mailed with a New York City return address.

Inasmuch as we have been individually and officially active as members of the Executive Committee of the Metropolitan Section in bringing the subject of Industrial Relations before the Society, we feel compelled publicly to disclaim any connection with or knowledge of this publication.

We deplore the issue of this anonymous booklet bearing the imprint of the Society's emblem. Not only do we consider that an improper use has been made of the Society's emblem, but we resent the discourtesy to the Council of our Society perpetrated in sending out such propaganda on a subject that is now before the Council for action and on which a special committee appointed by the Council is soon to report.

S. N. CASTLE W. C. BRINTON
G. K. PARSONS W. S. FINLAY, JR.
L. P. ALFORD F. T. CHAPMAN.

History of the Students' Army Training Corps

A review of the activities of the Committee on Education and Special Training has been published by the War Department. This records the history and general operations of the Students' Army Training Corps over which it had supervision from its inception on Feb. 10, 1918, until the completion of the settlement of the contracts made with colleges on June 30, 1919.

The report gives interesting information as to the personnel of the staff, the educational methods of intensive training in both vocational and collegiate divisions, the types of schools and equipment, costs, specialization curricula, rating and testing, course specialists, teachers, and the war-issues course.

Brig.-Gen. R. I. Rees was chairman of the Committee; Lt.-Col. Grenville Clark, secretary and executive officer. The activities were conducted by three major departments—the educational, the military and the business. The educational department was subdivided into three departments. Mr. C. R. Dooley was director of the vocational training division, the late Dr. R. C. Maclaurin, director of the collegiate training division, and Dr. Frank Aydelotte, director of the war aims division. The business administration was under the direction of Mr. E. K. Hall.

The Civilian Advisory Board included Dr. C. R. Mann, chairman; J. W. Dietz, secretary; Dr. J. R. Angell, Dr. S. P. Capen, Mr. Hugh Frayne, Dr. R. A. Pearson, Dr. Herman Schneider.

The demobilization of the S. A. T. C. was ordered on Nov. 23, 1918, and over three hundred thousand student soldiers in 680 educational institutions were returned to civilian status before Christmas, 1918.

Engineering Organization in India

The Indian Industrial Commission, which was appointed to consider the development of engineering works and industries in India, included in its report a recommendation of the formation of a Society of Indian Engineers which should include all branches of engineering. Last December, at a representative meeting of engineers held in Calcutta, the formation of such a Society was realized. All the existing organizations in India have decided to corporate in the new Society.

Engineering Society developments in India have been interesting. In a vast country like India where the engineers are separated by great distances, exchange of experience and access

to libraries is difficult and various efforts have been made to overcome these disadvantages.

It has been realized that the Government of India might on many occasions derive advantage if there were a recognized corporate body, representative of the engineering profession, which might be consulted upon such subjects as the education and training of engineers, the grants of concession for mining rights or water-power, the regulation of electrical supply undertakings, etc. The new Society of Indian Engineers hopes to be able to assume the responsibilities which would fall to such an organization.

Gift of $5,000,000 for Promoting Research

The Carnegie Corporation of New York has announced its purpose to give $5,000,000 for the use of the National Academy of Sciences and the National Research Council. It is understood that a portion of the money will be used to erect in Washington a home of suitable architectural dignity for the two beneficiary organizations. The remainder will be placed in the hands of the Academy, which enjoys a federal charter, to be used as a permanent endowment for the National Research Council. This impressive gift is a fitting supplement to Mr. Carnegie's great contributions to science and industry.

The National Research Council is a democratic organization based upon some forty of the great scientific and engineering societies of the country, which elect delegates to its constituent divisions. It is not supported or controlled by the Government, differing in this respect from other similar organizations established since the beginning of the war in England, Italy, Japan, Canada and Australia.

All are familiar with the great achievements in research which have been accomplished in Germany; but in that country research has been backed and controlled almost exclusively by the government, banks and a few large firms and organizations closely allied to the government, and it was these same firms and government which have mainly benefited by the results of the research. The objectionable features of the autocratic régime of the country have been carried into the organization of the research work and have materially affected the handling of its results.

The National Research Council hopes to achieve scientific results at least comparable to those which the Germans have achieved, and to accomplish this by democratic methods in consonance with the spirit of this country and to create a movement toward research work that may ultimately become general among small as well as large organizations. It is intended that the work shall become so coördinated as to make the results beneficial to the industrial life of the country generally rather than to a few large concerns, and thus stimulate economic research throughout the nation.

The National Research Council was organized in 1916 as a measure of national preparedness, and its efforts during the war were mostly confined to assisting the Government in the solution of pressing war-time problems involving scientific investigation. Reorganized since the war on a peace-time footing, it is now attempting to stimulate and promote scientific research in agriculture, medicine and industry, and in every field of pure science. The war afforded a convincing demonstration of the dependence of modern nations upon scientific achievement, and nothing is more certain than that the United States will ultimately fall behind in its competition with the other great peoples of the world unless there be persistent and energetic effort expended to foster scientific discovery.

Proposed National Labor Program

The three parties commonly regarded as closely related to the labor problem are the worker, the employer and the public. Mr. Henry Hess in this number (p. 185), recognizing that the problem is national in scope, proposes to add a fourth party—the Government—and advances a coöperative plan for reconciling the needs of all four. In this case, however, the role of the Government is not to be its usual one of adjuster of labor difficulties, but it is to play a more helpful and constructive part.

Mr. Hess believes that the trouble with labor is its inability to meet living expenses continuously; to save up against a day of unemployment and to accumulate funds against the period of old age. There are other issues, of course, but he holds that the fear of unemployment is basic.

On the other hand, he considers that an ideal condition would exist if labor and capital should divide equally their risks and responsibilities and share equally in the profits of industry. While this ideal is far from being reached, a few firms and their employees have advanced a long way toward this goal; and he feels that if such mutual coöperation should become general the groundwork would be prepared for a national plan whereby the demands, not only of capital and labor, but also of the public and the Government might be met.

His plan includes profit-sharing and provides for the accumulation of an unemployment fund to which labor would contribute a part of its share of the profits. The fund would be lent to the Government which would thus have placed at its disposal sums which it would not have to raise by taxation. Labor would benefit through ease of mind and insurance against time of need. Capital would benefit through stabilized business. The public would benefit for the same reason and because relieved of its burden of caring for the unemployed.

The engineering method in industry involves a study of facts and the formulation of a working plan before attempting to proceed with the work. In this proposal Mr. Hess has applied the engineer's method to a great economic problem, tempering it, however, by a recognition of the human characteristics involved. The proposal may or may not be practicable, but it is an attempt to solve a pressing national problem and so of timely interest.

Are Prices Coming Down?

The industry of the country has been built up during the last few years on the idea of high wages, high prices of raw materials, and high prices of manufactured products. Many devices of production have been adopted in order to operate economically under such conditions as were created by war demands and war shortages. There are various indications, however, pointing to an impending change in economic conditions. Some of these are quite faint as yet, while others are fairly plain to all who would read.

A careful analysis of the situation, given by *The Annalist* (Monday, Feb. 9, 1920), would indicate that the long expected fall in prices may be at hand. This view is based on considerations of events in the commodity and security markets. Cotton, corn, pork, lard, and other commodities were marked down substantially under dealings at Chicago, and there was also a material fall in the prices of stocks. It is also influenced by the fall in European exchange and consequent decrease in the export of commodities. *The Iron Trade Review* (Feb. 12, 1920) gives important facts which bear very materially on the same situation.

The difficulties of exchange have affected the situation in two ways. In the first place, foreign purchasers find the prices of American goods at the present rates prohibitive and are making shifts to do with as little imported goods as possible. A number of projects in which American raw materials and machinery were to have been used have been discontinued, and in other projects orders were placed where the exchange situation was less difficult than in the American market. Thus, it has become known that a large order for locomotives which was to go to an American concern was placed in England.

The same exchange difficulties have brought about a situation where banks refuse to accept bills based on sales abroad, except for collection only, which means that the concern selling abroad has to furnish its own capital to handle the transaction. Considering the length of time which must elapse until a transaction is completed and paid for, this situation imposes an excessively severe hardship on the exporter. The *Iron Trade Review* cites a case where a $5,000,000 sale of iron and steel goods to an

Italian customer broke down in face of such a requirement on the part of American bankers.

The same situation affects the export of foodstuffs. Not only can American foodstuffs not be exported in the face of a 25 per cent handicap on the exchange, but European foodstuffs, such as Danish butter, are finding their way to United States ports.

At the same time it should be clearly realized that so far the fall of prices has mainly affected articles in which there has been no domestic shortage, and of which the prices have been maintained either by sales abroad or by storage holdings for foreign markets actually or prospective. Where the article is such that there is or is likely to be a serious domestic shortage prices are not only not coming down but have an upward trend. Such is largely the case with steel, and fuel oil and its various products.

On the whole it would appear that the trend of business affairs has clearly begun to favor the consumer, who, however, has no way of estimating just how far this will extend. The consumer sees the beginning of price recessions and an active demand which may be stimulated by lower prices, and the manufacturer has to view the same situation. The question is how these forces will act in relation to one another.

Aeronautics in the United States

The impression appears to prevail that the state of aeronautics in America, as compared with that in Europe, is decidedly backward and in every way inferior. Developments on the two continents have been compared to the disadvantage of this country, both in regard to technical achievement and the government appropriations for aviation work.

The actual situation, however, from an American point of view, is far less disturbing than would appear. As regards appropriations, the situation is not good either here or abroad, although probably a good deal worse here than in Europe. The original appropriations in England and France were enormous, the appropriation in England being more than $300,000,000 for one year; but these appropriations have been very greatly cut down, partly because of the tendency to economize and also because of the growing feeling that important changes, mechanical and otherwise, in the aeronautical field are impending and that it might be well to await developments before incurring expenditures of such large sums.

In this country Congress has refused to appropriate any considerable sum for the present, and, in this respect, the situation is anything but encouraging.

The development of commercial aviation abroad has been of a more startling character and much better advertised than here. Thus, practically regular communication is maintained between London and Paris and a few other large cities. This is cited as showing the progress of aviation abroad. On the other hand, regular communication by aeroplane has been maintained in this country between New York and Washington for many months and is now being extended to Chicago. Our Forest-Service is employing aeroplanes with great effectiveness for the detection and combating of forest fires. On the Pacific coast power transmission companies use aeroplanes to locate and repair faults and breaks in transmission and telephone lines, especially in the mountain regions. Ranchers find communication through the air a great boon in inspecting widely scattered herds of cattle and sheep over trackless ranges where an automobile is often of little service. In Texas, oil men have also found the aeroplane of great advantage, both in inspecting widely scattered properties and in quickly reaching new fields where indications of liquid wealth have been located.

It would be fair to state that from the point of view of organization and results achieved the American developments are, if anything, carried out on a greater scale than the European.

In the field of straight commercial aviation the United States probably leads. Thousands of planes are already in use by the public for every-day commercial work and such large companies as, for example, the Curtiss, are literally working day and night and still have considerable difficulty in keeping up with the orders accumulating on their books. An encouraging feature is that a number of American aeroplanes and aeroplane parts have been sold or contracted for abroad, especially to South America, South Africa and China.

Comparing the number of aeroplanes sold to the public in their dollar value, America again leads. In making such a comparison it should be noted that only a very small number of war planes have been sold to the public and that the largest number of planes going for public use have been those built since the armistice and designed for peace purposes, a situation which is more favorable in every respect than that existing in Europe, where it is chiefly the discarded war planes which go for purposes of commercial aviation.

In this connection, rather significant statements have been made in British aeronautical papers in reference to the situation existing in Scandinavian countries. The conditions there favor the adoption of aeroplanes for communication between the islands in the North Sea and the inter-country and a considerable number of German planes were bought for this purpose. This was followed by a large number of accidents fatal and otherwise and when we learn that German discarded war planes have been bought with an extra engine for about $100 American dollars, it is very easy to conceive why their use has proved disastrous to aviators.

There have been several important technical developments in America to which the general public has not paid the attention deservedly due. One of the most significant of such developments was the tests carried out by the Navy Department, in connection with the Martin torpedo plane. This plane exceeded by far the requirements set by the Navy Department for its adoption and actually carried a torpedo weighing in excess of half a ton at a speed of 120 m.p.h. In fact, the results of these tests have been so encouraging as to point to the possibility of the torpedo plane entirely revolutionizing marine warfare. The torpedo plane is entirely an American invention and was proposed many years ago by a member of the American Navy.

Another important development has been refinement in the design and operation of the Liberty motor. In the months which have elapsed since the armistice a large amount of valuable work has been done on this motor whereby it has been brought to a high state of efficiency. The Liberty motor of today stands out as one of the great achievements of American engineering genius.

The wireless telephone for use in aviation is practically exclusively an American development and in the last year has been brought to an unusually high state of perfection.

In addition to these the most earnest consideration should be given to the important results achieved during the last two years in such research laboratories as McCook Field and the U. S. Bureau of Standards. Under the impetus of war and partly on funds provided by Congress during that period, a large number of important investigations on the stress of materials, fuels, electrical equipment of aeroplanes, etc., have been carried out, and now the American manufacturer of aeroplanes and accessories has a vast fund of information at his command; and what is, perhaps, more important, a number of men who have carried out investigations are cheerfully ready to give of their fund of knowledge to those wishing to use it in a legitimate way for the good of the country.

The first copy of *The Tech Engineering News*, published by the undergraduates of the Massachusetts Institute of Technology, has just been issued. It is a 16-page journal, 9 by 12 in. in size, published monthly, and its purpose is to provide a medium for the exchange of ideas between the Institute (the faculty, undergraduates and laboratory workers) and men of executive rank throughout the country. Its articles are intended to be of a character to interest practicing engineers as well as students, and to acquaint each with the needs and conditions of the other. The first issue contains a number of original articles of merit; some of them are strictly of a technical character, presenting new material, while others deal with the business side of the engineer's work, as in one contribution upon Possibilities for Civil Engineers in South America.

American Engineering Standards Committee Actively Engaged in Organizing Standardization Work

The American Engineering Standards Committee, organized in 1918 by representatives of the national engineering societies to secure coöperation and prevent duplication in the work of standarization, now has a revised constitution, with by-laws and rules recently adopted by the coöperating societies. These are of wide scope and allow the direct or indirect participation of any organization interested in standardization. Provision is made for direct representation on the Committee of additional organizations or groups of organizations.

The Committee's activities are already taking on an international character. It has approved specifications for standard pipe threads, for which The American Society of Mechanical Engineers and the American Gas Association are sponsors, and are representing America on this subject at an international conference in Paris. Coöperation is in progress with the National Screw Thread Commission, by which direct coöperative work with the British, not possible by the official Commission, is being carried out. The Committee is also in active coöperation with the Canadians on bridge specifications, with the British on specifications for machine tools, and with the Swiss on specifications for ball bearings.

A large conference, in which practically all national organizations interested in industrial safety participated, has unanimously voted that all industrial safety codes should be prepared under the auspices of the American Engineering Standards Committee. This was reported in the February number of MECHANICAL ENGINEERING.

How The Committee Operates

Any organization may request the Committee to approve standards which it has formulated, or to approve committees that it has appointed, and by so doing becomes a sponsor society. Two or more organizations may act as joint sponsors. Approval of the standard is given when it is the substantially unanimous conclusion of a section committee made up of representatives of producers, consumers and general interests, and so selected that all interests concerned have adequate representation on the section committee.

It is understood that a standard must be referred to as that of the sponsor, using whatever title the sponsor has given it, followed by the statement—"Approved by the American Engineering Standards Committee." The approval may be given in one of three ways: "Recommended Practice," "Tentative Standard" or "American Standard." The "approval" of a standard does not mean that the Committee has itself worked over and approved each detail, but rather that the work has been carried out by a sectional committee adequately representing the industry concerned, and sponsored by one or more bodies of ability, experience and standing, so that the result may stand for what is best in American engineering practice.

Any standard or group of standards adopted by any organization or in process of preparation, prior to January 1, 1920, may be approved by the Committee, if in the opinion of the Committee it has either been developed by a properly constituted committee, or has, by actual practice, proved its right to become a standard.

In addition to the work of assistant in the selection of committees and certifying that their work has been done under proper conditions, the Committee will act as a bureau of information regarding standardization.

Personnel of Committee

The Committee as it exists today consists of 24 members and includes representatives of the American Society of Testing Materials and of the Government Departments of Commerce, Navy and War, as well as of the founder Societies. Its former chairman, Prof. Comfort A. Adams, who has done painstaking work for the Committee since its inception, has been obliged to retire from this office because of the press of other affairs, and he is now succeeded by A. A. Stevenson, Past-President of the American Society for Testing Materials. Its secretary is Dr. P. G. Agnew, formerly of the U. S. Bureau of Standards, with headquarters in the Engineering Societies Building, 29 West 39th Street, New York. Until recently when it was possible to arrange for a permanent secretary, Prof. C. B. Le Page, secretary of the Standards and Technical Committees of the A. S. M. E., acted as volunteer secretary.

PROPER BALANCING OF FUEL, LUBRICANT AND MOTOR

(Continued from page 168)

will be entirely consumed on top of the pistons. Effecting compression of the air and gasoline outside of the cylinder, and igniting the charge upon admission and during the power stroke, would overcome practically the entire amount of fuel-and-air-mixture leakage that takes place during the compression stroke of the present four-cycle motor. Other methods will undoubtedly be proposed and worked out successfully as soon as the seriousness of the present situation is fully established.

Conservation of Lubricating Oil and Fuel

In the Air Service during the war the necessity existed for the conservation of lubricating oil, and a simple system of reclamation was designed and placed in the thirty flying fields in this country which brought about a considerable saving in oil and money. The records show that 40 per cent of the oil issued and used in the aeronautic engines was sent back to the reclaimers, and of that amount 73 per cent, and as high as 95 per cent, was reclaimed and made available for reuse, and the test records show that this reclaimed oil was, if anything, a better lubricant than the original new oil. The engines were cleaner after its use, 50 per cent of the field flying engineers stated the reclaimed oil was preferred to new oil; the other 50 per cent said it was just as good as new oil.

Oil reclaimers are commercially successful. It is only necessary to have steam for their operation. They should be installed in every commercial garage. Reclamation of motor oil can be carried on without trouble and at a cost not exceeding ten cents a gallon. The oil so reclaimed will be just as good a lubricant as when new, but will be dark in color and have a slightly burnt odor, correction of which will require expensive and elaborate equipment and is not at all necessary.

Where reclaimers are installed oil should be removed every day. Motors should be made with larger drains and with easy methods of draining and filling. In fact, it should be as easy to drain and fill a modern motor with lubricating oil as it is to fill the radiator with water or the tubes with air.

Devices to remove the dilution in the oil in the motor or in the reclaimer do not solve the main problem of economy of use of gasoline. This is squarely up to the motor manufacturer or the designing engineer. The solution must come through some entirely different mechanical use of the fuel.

Then the importance of the care of gasoline and lubricating oil must not be overlooked, and the useless wasting of even the smallest amount of gasoline or oil per car must be avoided.

We are dealing with a disappearing asset. The Bureau of Mines has sounded repeated warnings as to the reducing reserves. The oil age which we are now living in will be shortened if we do not conserve our supplies by every possible means, and conservation is squarely up to the engineers of the country, as it is necessary first to secure engines that will utilize more of the heat units of the fuel, and are so designed that mechanical losses in the use of the fuel will not occur. And it is up to the millions of car users to prevent the small losses per car which in the aggregate mean million of gallons of a product which is of prime necessity to modern industry.

Herbert C. Hoover Addresses Mining Engineers

Discusses Railroads, Shipping, Industrial Relations, and Other National Problems in which Engineers Are Directly Concerned

AS we go to press the American Institute of Mining and Metallurgical Engineers is holding its annual meeting, the feature of which has been the inaugural address of Herbert C. Hoover, delivered upon assuming the presidency of the Institute for the ensuing year.

In beginning his address Mr. Hoover spoke of the work which the engineers have done for the nation during the war and of the greater task now facing them.

"Even more than ever before," he said, "is there necessity for the continued interest of the engineer in this vast complex of problems that must be met by our government. We are faced with a new orientation of our country to world problems. We face a Europe still at war; still amid social revolutions; some of its people still slacking on production; millions starving; and the safety of its civilization is still hanging by a slender thread."

Mr. Hoover referred specifically to some of the great problems in this country in which engineers are interested. Brief quotations from these references are given below, as reported in the daily press. Speaking of the railroads and shipping, he said:

"The war nationalization of railways and likewise the war nationalization of shipping are our two greatest problems in government control awaiting demobilization. There are many fundamental objections to continuation of these experiments in socialism necessitated by the war. They lie chiefly in their destruction of initiative in our people and the dangers of political domination that can grow from governmental operation.

"Already we can show that no government under pressure of ever present political or sectional interests can properly conduct the risks of extension and improvement, or can be free from local pressure to conduct unwarranted services in industrial enterprise.

"On the other hand, our people have long since recognized that we cannot turn monopoly over to unrestrained operation for profit nor that the human rights of employees can ever be dominated by dividends. The problem is easy to state. Its solution is almost overwhelming in complexity.

"As the result of war pressure we will spend over $2,800,000,000 in the completion of a fleet of 1,900 ships of a total of 11,000,000 tons, nearly one-quarter of the world's cargo shipping. We are proud of this great expansion of our marine, and we wish to retain it under the American flag.

"Our shipping problem has one large point of departure from the railway problem, for there is no element of natural monopoly. Any one with a water-tight vehicle can enter upon the seas today, and our government is now engaged upon the conduct of a nationalized industry in competition with our own people and all the world besides. While in the railways government inefficiency could be passed on to the consumer, on the seas we will sooner or later find it translated to the national Treasury.

"Second, we may find it desirable to hold a considerable government fleet to build up trade routes in expansion of our trade, even at some loss in operation.

"Third, in order to create this fleet we have built up an enormous ship building industry. Fifty per cent of the capacity of our shipyards will more than provide any necessary construction for American account. Therefore, there is a need of obtaining foreign orders, or the reduction of capacity, or both.

"I believe, with most engineers, that with our skill in repetition manufacture, we can compete with any ship builders in the world and maintain our American wage standards; but this repetition manufacture implies a constant flow of orders.

Department of Public Works Essential

"Our joint engineering committees have examined with a great deal of care into organization of and our expenditure on public works and technical services. They report that the annual expenditure on such works and services now amounts to over $250,000,000 per annum, and that they are carried out today in nine different governmental departments. There is a great waste by lack of national policy of coördination, in overlapping with different departments, in competition with each other in the purchase of supplies and materials and the support of many engineering staffs.

"They recommend the solution that almost every other civilized government has long since adopted—that is, the coördination of these measures into one department under which all such undertakings should be conducted and controlled.

Industrial Relations a National Problem

"Another great national problem to which every engineer in the United States is giving earnest thought and with which he comes in daily contact, is that of the relationship of employer and employee in industry.

"We have until recently greatly neglected the human factor that is so large an element in our very productivity. The development of vast repetition in the process of industry has deadened the sense of craftsmanship and the great extension of industry has divorced the employer and his employees from the contact that carried responsibility for the human problem.

"I am daily impressed with the fact that there is but one way out, and that is to again reestablish through organized representation that personal coöperation between employer and employee in production that was a binding force when our industries were smaller of unit and of less specialization.

"Many of the questions of this industrial relationship involve large engineering problems, of which I know of no better example than that of the soft coal industry [a subject discussed by the A. I. M. & M. E. at their convention]. Broadly, here is an industry functioning badly from an engineering and, consequently, from an economic and human standpoint. Owing to the intermitteney of production, seasonal and local, this industry has been equipped to a peak load of 25 or 30 per cent over the average load. It has been provided with a 25 or 30 per cent larger labor complement than it would require if continuous operation could be brought about.

"There lies in this intermitteney not only a long train of human misery through intermittent employment, but the economic loss to the community of over a hundred thousand workers who could be applied to other production and the cost of coal could be decreased to the consumer. This intermitteney lies at the root of the last strike in the attempt of the employees to secure an equal division among themselves of this partial employment at a wage that could meet their view of a living return on full employment.

National Ideals Should Prevail

"These are but few of the problems that confront us. But in the formulating of measures of solution we need a constant adherence to national ideals and our own social philosophy.

"In the discussion of these ideals and this social philosophy we hear much of radicalism and of reaction. In their present day practical aspects they represent, on one hand, roughly, various degrees of exponents of socialism, who would, directly or indirectly, undermine the principle of private property and personal initiative, and, on the other hand, those exponents who in various degrees desire to dominate the community for profit and privilege. They both represent attempts to introduce or preserve class privilege, either a moneyed or a bureaucratic aristocracy. We have, however, in American democracy an ideal and a social philosophy that sympathizes neither with radicalism nor reaction as they are manifested today.

"For generations the American people have been steadily developing a social philosophy as part of their own democracy—and in these ideals it differs from all other democracies. This philosophy has stood this period of test in the fire of common sense; it is, in substance, that there should be an equality of opportunity—an equal chance—to every citizen."

The Engineer's Salary and Present Conditions

Compensation Should Be Based on the Value of the Dollar—How This Value Has Changed and Is Likely to Change—Underpaid Service a Menace to the Public

IN MECHANICAL ENGINEERING for February there was published (page 138) an abstract of the report of the Committee of Engineering Council on Classification and Compensation of Engineers. Herewith is published the main portions of an appendix to that report dealing with the important question of compensation from two different points of view: First, what increase should be made in engineers' pay to compensate for the great reduction in value of the dollar which has taken place in the last five years? Second, how may the intrinsic value of engineering service be determined?

I. THE DECREASE IN VALUE OF THE DOLLAR

A great deal of misunderstanding and injustice would be avoided in all our industrial relations were there a clear understanding of the fact that all prices today, whether of wages or salaries, or commodities, must be compared with the change which has taken place in the value of the dollar before it can be determined whether the price, measured by an absolute standard, has moved up or down. It should be obvious to every one that the value of the dollar is measured solely by its purchasing power. Whether it be a dollar received as wages by workmen, a dollar received as salary by an engineer, or a dollar received by a manufacturer in payment for goods sold, the actual amount of value which will be received in each case *will depend upon the average amount of other commodities which the dollar received will purchase.*

CHANGES IN WHOLESALE PRICES

The "Index Numbers" which are regularly published by various statistical bureaus are an average of the *wholesale* market prices of a large number of standard commodities. In making up the index numbers the prices of the different commodities and classes of commodities are weighted in proportion to the per capita consumption of each. Thus a comparison of the index number at a given date with the index numbers at preceding and following dates shows the change in average wholesale market prices and such a comparison shows also the change in the purchasing power, or value, of a dollar in the wholesale market.

TABLE 1 INDEX NUMBERS

Date	Dun's Index Number	Corresponding number indicating relative power of one dollar
Jan. 1, 1914	124,528	803
Jan. 1, 1915	124,168	805
Jan. 1, 1916	137,630	726
Jan. 1, 1917	169,562	590
Feb. 1, 1917	176,272	567
Mar. 1, 1917	186,244	536
Apr. 1, 1917	190,012	526
May 1, 1917	208,435	480
Aug. 1, 1917	218,779	457
Jan. 1, 1918	222,175	450
July 1, 1918	232,575	430
Oct. 1, 1918	233,227	429
Jan. 1, 1919	230,146	434
Mar. 1, 1919	217,037	460
May 1, 1919	222,193	450
July 1, 1919	233,707	428
Aug. 1, 1919	241,650	414
Sept. 1, 1919	238,342	419
Oct. 1, 1919	235,867	424
Nov. 1, 1919	238,573	419
Dec. 1, 1919	244,639	409

[1] From figures compiled by R. G. Dun & Co. from market quotations of wholesale prices of 300 standard commodities, showing variations in the cost of living and in the purchasing power of the dollar. In making up the figures the commodities are arranged in seven groups, as follows: (1) breadstuffs; (2) meat; (3) dairy and garden; (4) other food; (5) clothing; (6) metals; (7) miscellaneous. The price of each of these commodities is multiplied by a figure determined as the estimated per capita consumption of that commodity. The commodities listed under "miscellaneous" include such articles as coal, petroleum, building material, and drugs, so that the individual's expense for fuel and shelter is at least partially represented in the total. These index numbers published by R. G. Dun & Co. are believed to be the most reliable record obtainable of price changes in the wholesale markets.

This is illustrated in Table 1, in which the numbers in the last column, representing the buying power of a dollar, are the reciprocals of the index numbers. The index numbers in Column 2, it will be understood, are the amount of money required to buy a certain amount of certain standard goods at wholesale on a given date. Thus if the index number on a given date is, for example, $110, then on that date one dollar will buy 1/110 of this amount.

CHANGES IN RETAIL PRICES

In order to determine the change which has taken place in the value of the dollar it is necessary also to investigate changes in retail prices as well as those in wholesale prices. Especially where wages and salaries are concerned, it is the changes in retail prices that determine the buying power of the dollar received.

In general, the changes in retail prices follow the general course of the changes in wholesale prices. There is, however, more or less variation in different localites. Where such variation occurs it will generally consist in a *greater* proportionate increase of retail than of wholesale prices. Under the stimulus of the abnormal demand of the past five years, which is chiefly responsible for the great increase in prices, it is common knowledge that the retailer has frequently advanced his prices faster than the wholesale dealer.

CHANGES IN HOUSE RENTS

In the long run the prices paid for house rents and for personal service change to correspond with the change in commodity prices; but rents change more slowly than the market prices of commodities, so that allowance must be made for this "lag" in determining the change in value of the dollar. This is especially the case where such a sudden and rapid increase in market prices of commodities occurs as has taken place in the past five years.

Furthermore, the rise in rents varies in different cities. In some munition towns, rents rose with a bound in 1915, and so did prices for personal service. In most of the larger cities rents did not rise materially until 1919.

In order to determine accurately the change in value of the dollar in a given community, therefore, an estimate must be made of the change in retail prices compared with wholesale, and of the rate of change in rents and personal service charges.

The September Bulletin of the U. S. Department of Labor contains tables showing the results of the Department's investigation of the increase in the cost of living in 17 important industrial cities of the United States for December 1915, 1917, 1918, and June 1919 as compared with December 1914.

Averaging the figures for these 17 cities, it is found that the increase in the cost of living in June 1919 over December 1914 was 76.24 per cent. This so-called percentage of "increase in the cost of living" really represents the percentage of increase which has taken place in all prices, including rent and service, as well as commodities. Its reciprocal, therefore, represents the decrease in value of the dollar which has taken place.

PRESENT PRICES COMPARED WITH 1914

In order to compare readily these Bureau of Labor figures with the Dun index numbers, Table 2 has been compiled, in which the prices of December 1914 are taken as a base and the percentage of increase is shown for each date to December 1, 1919.

As explained above, the chief reason why the "cost of living" figures have increased less rapidly than the increase in commodity prices is the delay in readjustment of house rentals. The

TABLE 2 PERCENTAGES OF INCREASE OVER DECEMBER 1, 1914 IN WHOLESALE PRICES AND IN COST OF LIVING AT VARIOUS DATES

Date	Dun's Index No for wholesale prices per cent of Increase over Dec 1, 1914	Bureau of Labor's per cent of Increase in Cost of Living Over Dec. 1, 1914; Average of 17 Industrial Cities.
Dec. 1, 1915	7.2	1.07
Dec. 1, 1916	35.4	14.94
Dec. 1, 1917	77.4	41.81
Dec. 1, 1918	85.6	73.40
June 1, 1919	83.7	76.24
July 1, 1919	88.3	.....
Aug. 1, 1919	94.7	.....
Sept. 1, 1919	92.0	.....
Oct. 1, 1919	90.1	.....
Nov. 1, 1919	92.3	.....
Dec. 1, 1919	97.1	.....

Bureau of Labor figures bring down the record only to June 1, 1919. Since that date there has been a great increase in house rentals all over the country. There are no statistics to show the amount of this increase and its effect on the cost of living, but there is good reason to believe that this increase, coupled with the general increase in charges for personal service that has taken place during 1919, and the advance of prices by retail merchants at a greater rate than the wholesale price increases, is sufficient to make the percentage of increase in the cost of living indicated by the Dun statistics a true record of the change in value of the dollar at the present time.

There is still another item to be considered. The percentage of increase in wholesale prices shown in Table 2 records the increase over the prices on December 1, 1914. A more accurate comparison would be to take the average prices for the entire year 1914 as the base with which to make the comparison. The average of Dun's index numbers for the 12 months of 1919 was $122.20. The average wholesale prices of commodities on December 1, 1919, were therefore double the average prices for the year 1914. The value of the dollar today, therefore, in the wholesale market is just half what it was during 1914, and it is less than it was at any time during the war.

CHANGES IN "COST OF LIVING" AND IN "VALUE OF THE DOLLAR" ARE NOT THE SAME

The customary reference to the general increase of prices above reviewed as "the high cost of living" has tended to confuse the minds of many people. Some employers have argued that the high cost of living was not their affair. They have declared the real trouble to be "the cost of high living." On the other hand engineers or other professional workers, and many classes of salaried men, have hesitated to press claims for increased pay on the ground that changes in the cost of living make it difficult to live on their incomes. Such men rightly feel that their living expenses are their own private affair.

When, however, it is clearly understood that what has taken place is a change in the value of the dollar, the claim for an increase in the rate of pay measured in dollars rests on entirely different ground. The proper and dignified position for the engineer is to assume that his work should receive at least the same compensation in absolute value that it received five years ago and that, therefore, the compensation measured in dollars should be increased by whatever amount is necessary to offset the decreased value of the dollar.

There can be no denial of the justice of this claim, even though the difficulty of satisfying it to the full extent in many departments of engineering work is recognized. The compensation of many engineers is dependent upon laws and ordinances, custom and precedent. Great inertia must often be overcome to effect a change. In many cases the compensation of the engineer, like that of many other public servants, is dependent upon revenue raised by taxation; and the difficulties in increasing tax rates to correspond to the great decrease in the value of the dollar are known to everyone.

Engineers engaged in business on their own account have to meet the difficulty of raising their fees to offset the changed value of the dollar, a task especially difficult in fields of engineering where work is inactive and the competition for it is keen; yet without such increase they cannot adequately raise the pay of their own employees. This illustrates anew the need for emphasizing the change in value of the dollar, rather than the change in living costs. The former is at once recognized to bear directly on fair prices for goods sold and for the fees charged by professional men as well as on wages and salaries.

HOW LONG WILL HIGH PRICES STAY?

There has been reluctance to raise salaries to correspond to the changed value of the dollar because of the idea that prices were to drop back with the conclusion of the war. So far from this being the case, the above quoted records show that following the lull in business after the armistice prices have risen above even the war time scale and are now at the highest point ever reached. Business has largely readjusted itself to the changed conditions and the activity in some lines exceeds that registered during the war.

At the bottom of the changed price conditions is the surplus of demand over supply. The world urgently needs more food and coal and steel and cotton, more of the goods made from them and from other raw materials than are now being produced. The competition among buyers that sent prices soaring in the early years of the war is still an active force to maintain prices.

The only two things which can restore prices to their former level are increased production or decreased consumption. World wide disorganization of industry and of government, deficient capital and deficient transport facilities all tend to reduce production. The world of consumers, long held down to a war diet and war clothing, now eagerly seeks to replenish its larder and wardrobe and to repair and renew its stock of buildings and machinery.

The outlook is that it will take years to again organize the world's equipment for production and distribution, including finance, transportation by land and sea, and merchandising, so that the demands of consumers may be met as before the war and prices be brought back to former level.

The present price level is not considered merely temporary by such of our Government agencies as the Department of Labor and the Federal Reserve Board or by such economists as Irving Fisher and J. S. Holden. Substantial relief from the high cost of living, therefore, cannot reasonably be expected through a decrease in prices; it must be met by increases in salaries.

From such considerations as these, the Committee feels justified in urging that a readjustment of compensation should be based on the assumption that the present scale of prices is to continue for an indefinite time.

II. THE INTRINSIC VALUE OF ENGINEERING SERVICE

It will be generally agreed that the salary of an engineer ought to be at least sufficient to enable him to live in the manner which his position and responsibility call for, and in addition to repay within a reasonable time the investment in time and money he has made in gaining the education and experience which is necessary for his work.

Unfortunately there has been for fully a decade a tendency to lower the pay of engineers. The law of supply and demand has operated to reduce the pay of engineers in many branches of the profession far below the standards above defined.

By paying too low a rate for engineering service, the inevitable tendency has been to lower its quality. This has been especially marked in the case of engineers in Federal, State, and Municipal service. Here the inertia which prevails in all public affairs has prevented the engineers from receiving more than a trifling part of the increase in pay, measured in dollars, that is required to offset the shrinkage in the dollar value.

The obvious result has been to drive out of the public service the best and ablest men, who can obtain better positions elsewhere, and to leave only the men who by reason of age or inferior ability cannot make such a change.

CHEAPENED ENGINEERING SERVICE MEANS WASTE AND DANGER

It cannot be too strongly emphasized that the public loses through cheap engineering service many times the amount it may seem to save through lower salaries. The professional engineer in a responsible position in designing, constructing, or executive direction of important work should have initiative, sound judgment, broad knowledge, and executive ability. Lack of these qualities often results in great loss of money, often by needlessly increasing the cost of work of which the public never knows.

This matter deserves emphasis here because where readjustment of salaries has taken place to compensate for the changed value of the dollar it has been common to confine the increase to the lower paid men and to do little or nothing for the men receiving salaries above $2500 to $3000. There is no longer an excuse for this, as the above review amply proves. The measure of seeming economy, also, is very small: because the engineers in the higher positions are few in number compared with the rank and file of professional workers.

ROUTINE WORKERS IN THE PROFESSION

It is frankly recognized that there is another class of technical work of a routine order which calls for little in the way of initiative, originality, or judgment. Much of this routine technical work in the field, the office, the shop, or the laboratory can be and is being done by boys and young men with limited education and no more training than that afforded by a correspondence school or a few months study in a trade school. Most of this work does require, however, a degree of reliability and fidelity which deserves fair compensation. The best guide to fair rates of pay for this class of technical workers is found by comparison with the standard rates of wages paid to skilled workers in the trades. These workmen are now generally receiving rates of pay much higher than the routine technical worker and in many cases higher than even the engineer who carries large responsibility for design or administration.

The Federal Government is now paying thousands of its highly trained clerical and technical force less than a living wage. Except for the temporary bonus of $240 a year for positions paying salaries of $2,500 or less, no attention has been paid to the constantly diminishing purchasing power of the salaries paid to this class of employees. On the other hand the Government has given full recognition to increased living costs in fixing the wages of organized labor.

A "shipfitter" in the Navy Yard, for example, receives $1,750 a year while he is learning how to do his work. After three months of apprenticeship he gets $2,000. If he is made a "straw boss" in charge of 12 or more men, he gets $2,450, and if a "sub-foreman" in charge of 30 or more men, he gets $2,900. A blacksmith (heavy fire) gets $2,400. A "hammer and machine forger" (heavy) gets $3,700.

In many instances the amount paid for skilled labor is greater than the amount paid to the trained Government engineer. Over 40 of the labor crafts were awarded a rate of wage of $2,000 and more by the Labor Adjustment Board.

The skilled laborer is not required to know how to read or write, and he may receive full pay after an experience varying from two weeks to six months. The Government engineering employee, on the other hand, to get an equivalent amount of pay, must have had from two to eight years' experience, if he is not a technical graduate, and in many instances will not be admitted at all without a technical degree and then only with from two to four years' practical experience.

Even though a temporary oversupply of men trained in engineering work may make it possible to keep salaries for these brain workers below the wage of laborers, the inevitable result will be a dissatisfied working force, which carries out the daily routine without energy or good will, and the public's work will not be done with efficiency or economy.

Civil Engineers Discuss Development Problems

Features of Annual Meeting Are Discussions of Development Committee Report and Recommendations of Special Committee Appointed to Review It

THE Sixty-Seventh annual meeting of the American Society of Civil Engineers was held in New York on January 21 and 22. Chief interest centered upon the comprehensive report of the Committee on Development presented to the Board of Direction in October. The report of the Joint Conference Committee of the four Founder Societies was appended to the Development Committee's report and also came under consideration.

With regard to the technical activities of the Society the Development Committee recommended in part:

That local "sections" hold not less than four stated meetings per year and encourage joint meetings with kindred societies; that periodic joint meetings of the four national societies be encouraged; that the fortnightly meetings of the parent society be discontinued; that the semi-annual meetings of the parent society be supplemented by the addition of a spring and a fall meeting, held successively in different sections of the country in coöperation with local sections, and that at these meetings as well as at the Annual Meeting and the Annual Convention attention be given to technical and broad economic problems, and that at the Annual Convention at least half the time should be scheduled for the serious consideration of technical matters; that the present system of securing papers which depends wholly on voluntary offers and results in a limited variety of subjects be supplemented by papers that will fit into a definite logical program, directed by the Publication Committee and announced in advance for a whole season; and that papers describing works be brief on the narrative side, with more attention given to stating the technical lessons of successes and failures; that so far as practicable the subjects of the papers should cover current progress, and development of the various important branches of civil engineering and simultaneous discussion of important papers by the local section should be encouraged; that the monthly *Proceedings* should be extended to include editorial work, abstracts and reviews of important engineering articles and subjects of popular interest to the great majority of engineers; that coöperation with the American Engineering Standards Committee be approved and that it be continued and extended but that the idea of developing this Committee into another association be deprecated; that the Board of Direction be requested to consider the advisability of compiling a book of recommended principles of practice and standards to follow the development of engineering; and that to carry out the intent of these recommendations effectively the technical editorial staff be under the direction of the Publication Committee.

A special committee of the Board of Direction appointed to study the report of the Development Committee and review its suggestions, offered the following criticisms of the Joint Conference Committee Report, which, as it has been stated, was included in the report of the Development Committee:

1 The Joint Conference Committee's report does not sufficiently confine the voting power of the proposed new National Organization to the corporate members of the present National Engineering Societies, and of such other allied technical societies as are clearly predominately professional in their aim, and who are equally careful with the present national societies in the admission to their membership.

2 The proposed new organization does not have close enough connection and coördination with the officers and boards of direction of

the present national societies and such other national and regional societies as it may see fit to admit to its membership.

3 The Committee's plan creates a large amount of new, somewhat complicated, and expensive machinery that appears to us to be unnecessary, and which it may be reasonable to doubt can be made to work smoothly for some time to come, at least insofar as the present experience of engineering societies has gone.

4 The plan for the new organization is so drawn as largely to deprive the present national societies of any considerable influence in large public or national technical problems in which they are naturally interested and in which they are preeminently capable of having voice.

5 The plan commits the welfare of the engineering profession to a new and untried organization without history, precedent, or experience, from which semi-professional, and even semi-commercial local societies are apparently not only not barred, but possibly may become from time to time a predominating influence.

6 The representation in the new organization accorded to the four national societies is numerically insufficient in view of their numbers, experience and standing.

In view of these and other minor alleged objections, the special committee suggested that the officers and Boards of Direction of the present national and their affiliated engineering societies could form, ex-officio, a National Engineering Council for the purposes of professional unity, which would, in effect, continue the work of the present Engineering Council, and that to the council thus formed might be added, if desired, delegates from state and local councils to be formed throughout the country. [In this connection see also the account in this number of the Conference of the governing boards of the Founder Societies on January 23.]

The Board of Direction then voted that the main question in the Development Committee's report be submitted to the society for action by letter ballot as soon as possible. The resolutions of the Board included a suggested form of the questionnaire to be sent to the membership. The wording of the questions was modified in subsequent discussion and was finally adopted as follows:

1 Shall the American Society of Civil Engineers adopt the principle of becoming an active national force in economic, industrial and civic affairs?

2 Shall the Society actively coöperate with other engineering and allied technical societies in promoting the welfare of the engineering profession?

3 Shall the Society coöperate in the formation of the comprehensive organization provided for in the Joint Conference Committee report?

4 Shall the recommendations of the committee regarding technical activities be approved?

5 Shall the Society be divided into sections to embrace all members?

6 Shall the directors in each geographical district be nominated and elected by vote of the corporate members resident therein?

7 Shall a portion of the Society dues be allotted to local sections?

8 Shall the present nominating committee be abolished and candidates for the offices of president, two vice-presidents, and treasurer be nominated by representatives of local sections in annual conference?

9 Shall the dues of all non-resident members above the grade of junior be increased to provide for greater activities of the Society, said increase not to exceed $5 per annum?

A resolution was also passed authorizing the Board to add any questions that in its judgment were needful to develop the opinion of the members.

First Step Toward Federation of Engineering Societies

A Conference to Be Called Immediately of National and Local Societies to Formulate Plans for a Comprehensive Organization

AN important all-day conference of the officers of the four national engineering societies—the first such meeting ever held—was called in New York on January 23 by Engineering Council to discuss matters relative to the Council and its public work and to consider the broad question of engineering organization as reported in the recommendations of the Joint Conference Committee of the Founder Societies. The Trustees of the United Engineering Society, the members of the Joint Conference Committee and of Engineering Council were also present, the whole gathering numbering ninety-five leading engineers from all sections of the country.

The feature of the meeting was the passage of a resolution as a recommendation to the several societies approving the recent report of the Joint Conference Committee and calling for a conference in the near future of representatives of engineering organizations throughout the country to formulate plans for a federation of engineering societies. This is probably the most important and significant step which has been taken toward securing concerted action by the engineers of the country in respect to their common interests and their participations in public affairs. The wording of the resolution was as follows:

WHEREAS, This conference of national engineering societies has considered the recommendations of the Joint Conference Committee of the four Founder Societies, therefore, be it

Resolved, That the conference adopts in principle that report and requests the Joint Conference Committee to call, without delay, a conference of representatives of national, local, state and regional engineering organizations to bring into existence the comprehensive organization proposed.

VOTED unanimously that if this conference be called together again, it be called for a meeting in Chicago on April 20.

The conference on January 23 was called to order by Vice-Chairman D. S. Jacobus in the absence of J. Parke Channing, Chairman of Engineering Council, who was ill. Dr. A. R. Ladoux, Vice-President, Am. Inst. Min. & Met. Engrs., was elected chairman of the Conference.

FUTURE OF ENGINEERING COUNCIL DISCUSSED

A paper prepared by Chairman Channing, read at the conference, reviewed the main facts regarding the present organization and work of Engineering Council, covering important activities which have been reported from month to month in the columns of MECHANICAL ENGINEERING.

The financial needs of Engineering Council were outlined by Charles T. Main, Past-President Am.Soc.M.E. He stated that $45,000 was needed to continue the activities modestly for 1920, and $25,000 to reimburse Chairman Channing for money advanced during 1919 to inaugurate and maintain the Washington office; total $70,000. Total expended in 1919, $49,600. Resources for 1920 now visible are: balance from 1919, $900; appropriations by Member Societies, $12,600; contributions in response to 50,000 appeals to engineers throughout the country, $5,000; total $19,000. Needed, approximately $50,000. Whatever reorganization of, or substitution for Engineering Council may be made, the latter must continue as now constituted through 1920, and should be at the end of the year a well organized activity.

Resolutions were passed at the conference calling for the support of Engineering Council so that its present activities need not be curtailed. These were voted as recommendations to the several societies and asked for a contribution of $5,000 for the year 1920 in place of $3,000 as now provided; and further for $1,000 from the Am. Soc. for Testing Materials instead of $600. It was asked that appeals for contributions be made of $2 per person in each of the societies for the support of welfare work during the interval before the recommendation of the Joint Conference Committee shall have been made effective.

REPORT OF JOINT CONFERENCE COMMITTEE

Following these matters there was a general discussion throughout the afternoon of the report of the Joint Conference Committee. This report, an abstract of which was published in Section 2 of MECHANICAL ENGINEERING for January, 1920, is in two

parts, dealing respectively with public activities of engineers and with activities of common interest to the four Founder Societies. The conference devoted its attention to the former, which presented tentative plans for "a single comprehensive organization to secure united action of the engineering and allied technical professions in matters of common interest to them." Certain specific objects which such an organization might have were pointed out in the report to be as follows:

1 To render the maximum of service to the nation through unity of action.

2 To give the engineers of the country a more potent voice in public affairs.

3 To secure greater recognition of the services of the engineer, and to provide for his advancement.

4 To promote *esprit de corps* among the members of the profession.

5 To provide the machinery for prompt and united action on matters affecting the profession, among which are:

Registration of engineers;
Washington office for engineering societies;
Department of Public Works of the Government;
Conservation of national resources;
Publicity;
Classification and compensation of engineers;
General employment bureau;
Engineering education;
International affiliation of engineers;
Industrial relations.

Commenting on these the Committee says:

"In the greater vision resulting from the world war it is apparent that no one alone can successfully solve the problems with which he is confronted. He needs the coöperation of his fellows. National problems demand united effort. The Joint Conference Committee believes that the greatest value of the proposed organization is in the united effort for the service of the nation, from which effort will result the greatest service to the individual."

New Organization to Be from Bottom Up

The tentative plan for the proposed organization called for the following component parts:

1 Local Affiliations, preferably under the auspices of local engineering societies or clubs, as follows:

a "Local Associations" or "Sections" of the national engineering or technical societies;

b Local engineering societies; and

c Other local engineers and members of allied technical professions and associates.

These local affiliations when secured are to be headed up in:

2 A National Council, consisting of representatives of national engineering and technical societies and of representatives of local, state or regional affiliations or organizations.

State councils were also recommended wherever and whenever the local conditions warrant.

The proposed basis of representation on the National Council is for each local, state or regional affiliation or organization whose membership is not otherwise represented than through the national engineering or technical societies to have one representative to the National Council for a membership of from 100 to 1000 inclusive, and one additional representative for every additional 1000 members or major fraction thereof.

Each national engineering or technical society is to be entitled to one representative for a membership of from 200 to 2000 inclusive, and an additional representative for every additional 2000 members or major fraction thereof.

Engineering Council Might Be Merged

In reference to the present Engineering Council, whose work has been so effective in the many matters of general concern among engineers, the Committee states:

"In preparing this plan the Committee has recognized that there exists in Engineering Council a tool which is engraving an honorable record on the pages of professional history, but its limitations are well known and its poverty is chronic. If desired, Engineering Council can be moulded into this organization by making it more democratic and founding it on direct representation of all engineers, rather than appointment as at present.

The great object is to provide an effective body, widely and truly representative, modestly yet adequately financed, which will be neither autocratic nor aristocratic, which will at all times stand as the representative and defender of the profession in matters affecting its honor, welfare and common interest."

J. W. Alvord, Chairman of a committee appointed by the Board of Directors of the Am.Soc.C.E. to study the report of its Committee on Development and make recommendations with regard to it, presented the conclusions of this Committee, saying that the problem is first to consolidate the engineering profession within itself by knitting together the Founder Societies and other national societies equally broad in purpose and careful in membership; second, to affiliate semi-technical societies in such a way that they will not control. He said that the new organization proposed by the Joint Conference report is quite separate and distinct from the Founder Societies and that he would propose to depart from that Committee's plan by consolidating into the new National Council the directors and officers elected by the Founder Societies. To this and other similar proposals by various speakers objection was raised on the ground that an organization such as proposed by Mr. Alvord would not be democratic, builded from the bottom up, in a way to satisfy the urgent demands of the various organizations of engineers both large and small.

Discussion on Joint Conference Report

At the conference the plans of the Joint Conference Committee, certain of which have been referred to above, were presented by J. V. W. Reynders, who said that:

"First, the movement should be democratic, and so far as possible membership of the Engineering Council should not be appointed on the new Council. Second, the plan should not be fathered by the Founder Societies more than necessary in order to avoid hurting the susceptibilities of those not affiliated with these societies. Any nation-wide movement will fail unless it is the outcome of a justifiable, as well as an enduring principle. There must first be an unmistakable and widely-felt sentiment. There must be plainly recognizable signs of powerful initiative. In the national societies are sufficient members to insure success of this movement. This is a constituency upon which we can build without fear of consequences."

Further discussion, in which a large number participated, hinged upon the form which the proposed organization should take; that is, whether it should be in some way related to the present Engineering Council through the reorganization of the latter or otherwise organized through the present governing boards of the national societies; or whether it should be based on initial action taken by membership of the leading societies both national and local as proposed by the Joint Conference Committee. The drift of the discussion can be summarized by brief reference to remarks by Dr. Jacobus, who said the great handicap on Engineering Council has been the feeling that it is organized from within. The moment we say we are going to reorganize Engineering Council it will spread a feeling abroad that Council is going to fix things to suit itself. It should come from without, not within.

Another question raised was the matter of representation on the National Council of the proposed organization, whereby the local representation is much larger than that of the national societies. To this R. L. Humphrey of the Joint Conference Committee replied that the members of the best local societies are so often members also of the national societies that the delegates from the local organization would usually be members of the national societies as well and that therefore the latter would be amply represented. He believed that it would add to the feeling of democracy if the men from the local affiliations had a larger proportion of representation on the National Council. It was specified in the report, however, that the local representation on the Executive Board would be more restricted.

Government Activities in Engineering

Notes Contributed by The National Service Committee of Engineering Council[1]

Congress Passes General Land Leasing Bill

After ten years of waiting, the General Land Leasing Bill has passed both houses of Congress, run the conference gauntlet and was finally accepted by the Senate on February 11th.

It is estimated that by the terms of the bill, the oil, gas, coal, phosphate, sodium, and oil-shale lands made available for leasing and development by private enterprises are approximately 75,000,000 acres of the public domain. This land is largely in the western states.

The conference report reserved the right of the Government to extract helium from all gas produced from such lands. A Senate provision was put back in the bill permitting individuals, or associations of individuals, to obtain limited licenses or permits to secure a supply of coal for strictly domestic needs.

The relief section of the bill relates to very valuable oil-producing lands, which are now involved in litigation. The purpose of the House language, which was finally retained, was to prevent the claimant or holder of excess acreage from disposing of such excess. This excess under the terms of the House bill would revert to the Government to be leased by competitive bidding. At the same time it does not prevent one, holding not more than the maximum amount allowed, from disposing of any part thereof. It also recognizes an exchange of interest in lands made prior to January 21, 1920, provided the exchange does not increase or reduce the acreage held in excess of the allowed maximum. Thus the status quo of the excess holder is not changed. It was thought best not to interfere with sales of oil lands which were made by claimants holding less than the maximum amount allowed. The Senate provision requiring substantial improvements to have been made prior to an oil-land withdrawal in Alaska was reinserted in the bill.

The Senate provision provided maximum charges by the Government of 20 cents per ton for coal, and 25 per cent of the value of oil produced. The House bill contained no restriction on these charges and the conference agreed to the House provisions. It was finally agreed that 70 per cent of the proceeds from past sales, bonuses, royalties, and rentals was to go to the reclamation fund and 20 per cent to the State. Of the proceeds from future receipts, 52½ per cent is to go to the reclamation fund and 37½ per cent is to go to the State. Ten per cent of both past and future funds is to be turned into the United States Treasury.

It will be recalled that this bill provides for leasing lands on the public domain in multiples of 40 acres, and the total allowed to any one claimant is not to exceed 2560 acres.

Reclamation Service

The Reclamation Service has submitted supplemental estimates for $5,000,000 to be expended during the fiscal year 1921. The Secretary of Interior's letter of transmittal pointed out the limitation on the Reclamation Service due to the money available in the Reclamation Fund. At the time the regular estimate was submitted it was anticipated that not more than $7,873,000 would be available. When it became certain that the General Land Leasing Bill would become a law, it was possible to add at least $5,000,000 more to the estimate, because the reclamation fund is to receive 70 per cent for past production and 52½ per cent for future production derived from the bonuses, royalties, and rentals provided in the General Land Leasing Bill. It is estimated that this will make between $5,000,000 and $7,000,000 additional available in the reclamation fund.

[1]Engineering Council is an organization of national technical societies created to consider matters of common concern to engineers as well as those of public welfare in which the profession is interested. The headquarters of Engineering Council are located in the Engineering Societies Building, 29 West 39th Street, New York City. The Council also maintains a Washington office with M. O. Leighton, chairman of the National Service Committee in charge. This office is in the McLachlen Building, 10th and G Streets, Washington, D. C. The officers of Engineering Council are: J. Parke Channing, *Chairman*; Alfred D. Flinn, *Secretary*.

Patent Legislation

Legislation covering the administration of patent law, the status of the Patent Office, and our international relations in patent work have been very active in Congress. The House has passed a bill ratifying a Patent Convention which will enable holders of patents in this country and South American countries to have their patents registered and cleared through a common office at Havana. The registration fee is very small—only a fraction of what it formerly cost to have these patents registered.

The Senate and House bills authorizing the Federal Trade Commission to accept and administer inventions, patents, and patent-rights have been reported to both Houses. This is for the purpose of benefiting and encouraging the public in an effort to stimulate inventions and to encourage their industrial use. This bill provides for coöperation as between individuals, Government, and other agencies, and with scientific agencies of the Government. The House patent bill providing for increase of force and salaries in the Patent Office has been rewritten and reported to the House calendar. It provides that the Commissioner of Patents shall receive $6000 annually, the First Assistant to the Commissioner $5500, and the Assistant Commissioner of Patents $4500. Five examiners-in-chief are also provided with a salary of $5000 each. Salaries of other officials are raised in proportion.

The bill proposing to establish a Court of Patent Appeals has been re-written by a sub-committee of the House Patents Committee and will be introduced to the House calendar shortly. A bill proposing to make a separate establishment of the Patent Office is now under consideration by another sub-committee.

Tariff Legislation

Despite the fact that the Senate had threatened not to take up piece-meal tariff legislation, much of which had been passed by the House, some important tariff bills relating to magnesite, cobalt, chrome, zinc, tungsten, porcelain and scientific instruments have been ordered favorably reported by the Senate Finance sub-committee to the full committee. Some of these emergency tariff bills have been reported without change.

The magnesite bill provided one-half of a cent per pound on commercial ore; three-fourths of a cent per pound on calcined, deadburned and grain magnesite, and 10 per cent ad valorem and three-fourths of a cent per pound on magnesite brick. These are the same as the duties provided in the House bill. Laboratory, optical and scientific glassware also carry the same ad valorem duties as provided by the House, namely, 60 per cent on laboratory apparatus; 45 per cent on optical glass; and 45 per cent on scientific instruments.

The zinc bill was amended so that zinc-bearing ores of all kinds are to pay a duty of two cents per pound on the zinc content instead of one cent, as provided by the House bill. The bill was also amended to carry the cobalt duty of twenty-five cents. The tungsten bill was amended so as to provide for a duty of $1.50 on the tungsten content of imports of alloy steel.

Government Aid in Road Building

A new bill has been introduced by the Chairman of the House Military Affairs Committee which is intended to liberalize the conditions under which surplus motor vehicles may be transferred to the State Highway Departments. The bill provides for transfer of equipment other than motor vehicles, and is in accordance with the recommendations of the Bureau of Public Roads, which recently expressed its desire that the following materials be itemized in the bill, which in other respects is similar to the bill that has passed the Senate. The list of materials includes industrial railway equipment, conveyors, gravity, power, donkey engines, corrugated metal roofing, steel and iron pipes, etc.

Charles Warren Hunt Appointed Secretary Emeritus of the American Society of Civil Engineers

AFTER serving the American Society of Civil Engineers for twenty-eight years, three as Assistant Secretary and twenty-five as Secretary, Dr. Charles Warren Hunt, at this own request, has been relieved from active duty. Dr. Hunt will continue to serve in an advisory capacity. His relation will be that of Secretary Emeritus, this office having been created for him by the Board of Direction of the American Society of Civil Engineers by a resolution passed January 21, 1920. The text of the resolution follows:

WHEREAS, Dr. Charles Warren Hunt, after 25 years of devoted and efficient service as Secretary of the American Society of Civil Engineers, during which he has contributed to its upbuilding and prosperity to a degree which places the Society under lasting obligation to him, has indicated his desire to be relieved from active duty, and

WHEREAS, He possesses an intimate knowledge of the business of the Society and an extensive acquaintance with its membership which render his advice and assistance of the greatest value to the Society and its Board of Direction, the benefit of which they can ill afford to lose, therefore be it

Resolved, That Dr. Charles Warren Hunt be and hereby is appointed Secretary Emeritus of the American Society of Civil Engineers at a salary of $9000 for the coming year, and a salary of $6000 per annum thereafter with such duties as the Board of Direction may assign to him.

Throughout his administration, Dr. Hunt has kept closely in touch with the business details of the Society's office and its organization, and has conducted its affairs on sound business lines. The high professional standards of the Society have been maintained, and under his guidance and strong personality the Society has grown, not alone in numbers, but in professional prestige as well.

Dr. Hunt was born in New York City on May 19, 1858 and when only eighteen years old was graduated from New York University with the degrees of B. S. and C. E. This was in 1876, and for the next sixteen years he was engaged in the practice of his profession. His experiences were varied and included work on municipal parks, water works, railroads, and docks.

It was while associated with the Brooklyn elevated railway companies in 1882 that Dr. Hunt was elected Assistant Secretary of the society. This was a newly created office and while its acceptance meant financial loss he saw an opportunity to serve his fellow men and he did not hesitate to accept. From that time on the events in his career are intimately connected with the history of the American Society of Civil Engineers.

Bringing to the society the enthusiasm of youth, Dr. Hunt had well conceived ideas of the functions of a national engineering society. He believed it necessary for a technical society not only "to advance engineering knowledge and practice" but "to preserve the high character and professional qualifications of its membership; to maintain the dignity and standing of the organization; to keep in touch with and take proper action on all matters in which the relation of the Profession to the public is involved; and to do whatever is possible for its members individually and in general." This was Dr. Hunt's creed and to the realization of such ideals he devoted himself unstintingly.

Among the many developments which took place during Dr. Hunt's administration was the creation of Local Associations of the society. The formation of such associations had several times been considered, but it was not until 1905 that definite action was taken. In that year two associations were formed, one at Kansas City and the other at San Francisco. Their great success at once led to the formation of similar bodies in other cities, and at the present time the society has a total of twenty-five.

The house at 57th Street, which for over twenty years served as headquarters of the society, was also erected during Dr. Hunt's term of office. It was a building suited in every way to the needs of the society and only because of a desire to more thoroughly coöperate with the other national engineering societies was it vacated in 1916, when the American Society of Civil Engineers became one of the Founder Societies with headquarters in the Engineering Societies Building, 29 W. 39th St., New York.

To Dr. Hunt the society is indebted for the cataloging of its Library. He early realized the importance of a library index and after two years of careful and concentrated effort completed the work which made the library of great use to the profession. Dr. Hunt was also a pioneer in the making of engineering "searches," a work which has now become so important in all engineering reference libraries.

CHARLES WARREN HUNT

During Dr. Hunt's term of office the publications of the Society have undergone several changes. In 1892, in addition to the regular *Transactions*, the *Bulletin* dealing with current events and containing short abstracts of the technical papers was begun. In January, 1896, the publishing of the monthly *Proceedings* was started, the technical matter contained in these being subsequently collated and published in volumes of *Transactions*. This method of handling society notes and technical papers was new in society publications, but it soon won universal approval and has been retained ever since. In 1899 the society began the publication in the *Proceedings* of a "list of current engineering articles of interest." This service, started in a modest way, was greatly appreciated by the membership and has been retained ever since as a monthly feature.

Dr. Hunt has always taken the greatest interest in matters pertaining to the profession at large. In 1903, when The American Society of Civil Engineers was invited by the Directors of the Louisiana Purchase Exposition to undertake the arrangements for an International Engineering Congress, he personally supervised and directed the work of organizing the congress, the securing, translating and publishing of papers, the reception and entertainment of foreign representatives, and the details of the many meetings.

Dr. Hunt has long served as a representative member on such bodies as the John Fritz Medal Board of Award, the Engineering Foundation, and the United Engineering Society. He has given freely of his time and energy for the advancement of the entire engineering profession, and his active participation in the affairs of the profession will be greatly missed.

NEWS OF THE ENGINEERING SOCIETIES

American Society of Heating and Ventilating Engineers—The Engineering Institute of Canada—A. S. M. E. Akron Meeting—Engineering Society of Western Massachusetts

Engineering Society of Western Massachusetts

A meeting of the Engineering Society of Western Massachusetts was held at Springfield on January 20, at the Springfield Gas Light Company's plant, State and Water Streets. A number of the members visited the plant in the afternoon. Following a dinner in the office building of the plant, an evening session was held at which Arthur S. Hall gave a description of the plant and Harold C. Andrew, an efficiency expert, spoke on Chemical Control of the Gas Industry.

American Society of Heating and Ventilating Engineers

The twenty-sixth annual meeting of the American Society of Heating and Ventilating Engineers was held in New York on January 27, 28, and 29. The reports of the officers and council reflected the increased growth of the society during the past year. The society's Journal, beginning with the month of January, will be published monthly instead of quarterly. The Research Bureau of the society is now a functioning institution, as was evidenced by the data on heat losses from direct radiation presented by Director John R. Allen and given in part in the Engineering Research section in this issue.

The results of four years' experience in prevention of corrosion of pipe in the deactivating plant of a 12-story apartment building in New York City, were presented by F. N. Speller and W. H. Walker. The principle employed is to fill a storage tank with suitably prepared steel lathing designed so as to pack closely with an exposed surface of approximately 100 sq. ft. per cu. ft. of space. In passing the water heated to 160 deg. fahr. through this metal, all the oxygen is fixed in the form of hydroxides which are readily removed by filtration through a sand filter. The result is water inactive toward iron or other metals, free from oxygen but otherwise unaltered in composition except for the presence of a small amount of free hydrogen resulting from solution of iron in the deactivating tank. The results have been entirely satisfactory. It is said the pipes carrying deactivated water have shown no measurable corrosion.

E. R. Knowles described various types of installations using pulverized fuel, and quoted figures indicating to what extent this form of fuel is being utilized. It appears that in the United States there have been used to date over 50,000,000 tons of coal in powdered form; there are about 6,000,000 tons of powdered coal now used annually in cement making; about 2,000,000 tons in copper roasting and smelting; about 2,000,000 tons in steel manufacture and about 200,000 tons for general power.

An Advance in Air Conditioning in School Buildings, by E. S. Hallett, carried the general note of progress into the field of school ventilation and presented a system of using ozone in a way apparently so reasonable and convenient that it undoubtedly points out an economical solution to the problem of improving health conditions in schools.

National consciousness was appealed to in two papers. The first, The Coöperative Movement, by James P. Warbasse, president of the Coöperative League of America, discussed this great world movement of coöperation, tracing its history through humble beginnings to the present prosperity which it now has in England, Belgium and other countries, and pointing out the steady progress it is making in the United States. The other paper, Work of the Construction Division of the War Department, by Major R. W. Alger, gave an account of the difficulties under which this division worked and the almost incredible things accomplished under such handicaps. It concluded with a plea for constructive planning rather than destructive criticism in order that the country might be prepared should another great emergency overtake it.

Other papers were: Relations of Boiler Heating-Surface Area to Boiler Capacity, by P. J. Dougherty; Oil as a Fuel for Boilers and Furnaces, by H. H. Fleming; Oil Fuel, by F. W. Staley; Fuel-Oil Equipment, by John P. Leask; Oil Fuel versus Coal, by David Moffat Myers; Oil Fuel, by W. C. McTarnahan; and Color Schemes for Distinguishing Plant Piping, by H. L. Wilkinson.

A Record Meeting of Canadian Engineers

The Annual and Professional Meeting of The Engineering Institute of Canada held in Montreal January 27, 28 and 29 was easily the most successful in the history of The Institute. In view of the fact that the percentage of members lost in the war was very appreciable, the attendance of over 450 was especially good. The unusual attractiveness of the social features is explained by the statement that this is the first year that ladies have been invited to attend and participate in the events of the week. The professional papers were both varied and important.

The program for the Annual Meeting, held on the first day of the convention, included, in addition to the business sessions, an address on Modern Highway Problems, the address of the retiring president, Colonel R. W. Leonard, and the inauguration of the incoming president, R. A. Ross. At a luncheon held for members and guests, greetings from The American Society of Mechanical Engineers were conveyed to the gathering by Calvin W. Rice, Secretary of the Society, who stressed the importance of all technical engineers becoming members of The Engineering Institute.

During the past year, The Institute has been coöperating with other engineering societies in an effort to secure for Canadian engineers a uniform registration law similar to that recently recommended by Engineering Council in this country. The monthly Journal of The Institute is now well established, provincial divisions including 18 branches are now actively working, and the membership has increased greatly in excess of previous years. During his recent visit to Canada the Prince of Wales accepted honorary membership in The Institute and Government official recognition of The Institute was accorded by the Minister of Labor in granting it representation at the Industrial Conference at Ottawa in September.

The Professional Meetings of the convention opened Wednesday, January 28, in one of the most important sessions, a discussion as to whether engineering training should be specialized or conducted in a general manner. Papers were presented by Profs. R. F. Ruttan and A. S. Eve, of McGill University. Dr. Ruttan spoke favorably of the plan adopted by the Massachusetts Institute of Technology whereby the student while still under the direction of the instructors leaves during the winter of his Junior year and for the period of from two to three months in each of four or five leading companies' works under actual conditions in the field, returning the following winter and completing his college course. The general feeling evidenced by the discussion was that the engineering graduate should be a man competent to "take up a thing and see it through."

Engineering activities in the province of Quebec were dealt with at the Thursday morning session of the convention. The water power resources, the public health administration and the highways of the province were the subjects discussed. In the afternoon three interesting papers were presented, The Policy of the Air Board of Canada, Pulp and Paper Industry and The Forests of Quebec.

Several important points touching upon the situation in the engineering world today were brought out in the address of the retiring president, Colonel Leonard. He emphasized the need for

the engineer's clear thinking, always working from cause to effect, to help settle the labor unrest of the present time and quoted from an address which W. R. Ingalls gave before the Canadian Mining Institute to the effect that the increase in production which has come about during the last century is not because men have grown any stronger but because mind has taught labor how to become more effective and has provided it with machines and organization. Further progress depends on the ability of the leaders of labor to instill the sound principles of an intelligent democracy into their followers so that they may have a sense of their duties and responsibilities to the public as well as their rights. He said, "If solutions are possible whereby the lot of the workingman can be improved, the engineer—whose training and life work are devoted to the solution of practical problems—is the most capable of finding them."

Colonel Leonard urged coöperation among all classes and nations. He not only outlined various opportunities for Canadian engineers in Canada but importuned them to turn to engineers of other nations for advice and thus increase their usefulness. This suggestion, as applied between the engineers of the United States and Canada, would be for the greatest good of the development of the engineering profession in both countries.

We congratulate The Engineering Institute of Canada on its wonderful prospects and are grateful for the words of an appreciation in its annual report for the address last year of our past-president Dr. Hollis, and for the benefit which it obtained from the coöperative arrangements with our Society with respect to the Engineering Index.

A. S. M. E. Meeting at Akron

Cleveland members of the A.S.M.E. and members of the Cleveland and Akron Engineering Societies held an all-day convention in Akron on Tuesday, January 27, headquarters being established at the Firestone Club House, where the professional session was held.

A paper, illustrated with slides, was presented by John Schaub, superintendent of the Akron plant of the Wellman-Seaver-Morgan Company, on the subject Rubber-Working Machinery. The paper, while utilizing as examples the heavy type of machinery common to rubber-working plants, was more correctly a discussion of the application of quantity-production methods to the machining of parts usually considered large enough to be run singly through the shop as separate jobs.

In the Wellman-Seaver-Morgan plant mixing mills are carried through the machine shop in units of five for the larger castings, such as housings, mill boxes and driving gears, while the smaller parts are worked in lots of two or three times that number. In the design of these parts such clearances are specified that practically all the patterns may be used for machine molding.

Before planing the mill housings for their final fit, they are run through a milling machine and the larger portion of the surplus cap stock taken off. Then, when the housings are set on the planer, in lots of ten, there remains but a finishing cut. Machine time is cut appreciably by using two set-ups and two different machines for roughing and finishing. Mill bearings are gang-planed in lots of twenty, after which the pad for the bearing cap is milled and the individual bearing set for the final boring.

Mill guides are first planed, then dropped into a drill jig for drilling, after which they are placed on a special angle fixture on the horizontal boring-mill table, the drilled holes being used as a register to hold the guides in position. A complete set of guides with the guide tees adjusted is bored at one setting. The boring bar is fitted with two tools, one for each mill-roll radius, so that when the guides which fit on the large roll have been bored the operator moves the table sufficiently to place the other pair of guides in line with the boring bar.

A bonus system for machine-time saving is in successful operation, and all saving on the estimated time is split with the workman on a fifty-fifty basis, who receives as additional compensation one half of the time saved, at his hourly rate.

Calenders are also built in lots of five and erected on a cast-iron floor to insure correct alignment. A dummy roll, considerably lighter than the service roll, is used for scraping in the bearings to a perfect fit, eliminating much of the laborious work usually connected with roll fitting.

The calender is divided into units for assembling smaller parts, such as wind-ups, let-offs and roll-raising mechanisms, being put together by special assembly groups, after which the completed sectional units are brought to the erection floor for assembly.

A. O. Austin, of the Ohio Insulator Company, Barberton, Ohio, presented a series of slides illustrating the Ohio Insulator plant and gave a brief description of the purpose and operation of each machine shown.

Following a luncheon at the Firestone club house the convention divided into three main inspection groups. One section of about thirty members visited the plant of the Ohio Insulator Company, under the guidance of Mr. Austin, and had an opportunity to view the manufacture of large porcelain insulators, ranging in height from two inches to almost five feet. A demonstration of high-tension insulator testing was given, a voltage of 330,000 volts and a frequency of 35,000 being used. This voltage produced a standing spark 36 in. or more in length. During the test a novel feature was introduced by subjecting the insulators under test to all the conditions met in a severe rainstorm.

The group electing to inspect the Wellman-Seaver-Morgan plant was taken first to what is known as the "Old Plant" building and there shown two 52,000-hp. hydraulic turbines under construction, both for use at Niagara Falls. The magnitude of these turbines is shown by the fact that the cast-steel spiral casings have a water intake 7 ft. 6 in. in diameter. Other machinery under construction included rubber-mixing mills, calenders, washers, steam tire-vulcanizing presses, condensers for marine engines still being built for the U. S. Merchant Marine, and also the first lot of "Akron" tractors to be sent through the plant.

Passing through the galvanizing room, containing a tank capable of holding 100 tons of metal, and one of the largest in the country, the party completed its tour by inspecting assembly methods used in constructing mechanically stirred gas producers.

For the rubber-working industry the Goodyear Tire and Rubber Company acted as host, groups of eight men and a guide being sent through the plant, following, as closely as possible, the flow of the rubber through the plant from the raw material warehouse to the finished product. The manufacture of two types of inner tubes was shown, of lapped tubes—formed from sheet rubber much as lap-welded pipe is formed from skelp—and of laminated tubes, these latter being made up from a thin sheet of prepared rubber which is rolled around a mandrel of the proper size until it is covered by two or more complete layers. Both types were steam-vulcanized.

Guides for the inspection groups were taken from the organization in the Goodyear plant known as the "Flying Squadron," made up of high-school and college graduates, working out a kind of engineering apprenticeship with a view to being located eventually in the department most attractive to them individually.

The evening dinner was served at the Goodyear plant, with Dean Ayer, president of the Akron Engineering Society, as toastmaster. Dr. D. C. Tremaine, from the National Industrial Speakers' Bureau, discussed the topic, Human Nature in Industry. Introducing the factor of the human element in industry, the speaker brought out its present status, as compared to that of business, and emphasized the need for easy access to the manager's office by the worker. The responsibility for present-day business is not one-sided, but rests equally with worker and management. The growing importance of each man to the organization and to the industrial life of America was shown in its bearing on the relation of increased production to the high cost of living.

While the day's program was styled a "convention," there was nothing in the papers presented, the talks, inspection trips or the evening dinner to render it in the least bit formal. Primarily, the day was planned to afford an opportunity for engineers of Cleveland to meet engineers of Akron, and for them to enjoy together a glimpse into some of the industries which are typical of the manufacturing progress of the Rubber City.

Western Society of Engineers Holds Annual Meeting and Discusses Projects for an Engineering Building and Affiliation of Sections with the National Societies

The fiftieth annual meeting and dinner of the Western Society of Engineers was held in the Hotel Morrison, Chicago, January 28. Four hundred members of the Society were in attendance.

Major General Leonard Wood, U. S. A., the principal speaker of the evening, declared that the establishment of a National Department of Public Works would be of great benefit to this country. He said the Engineer's Reserve Corps should be maintained at maximum strength, for it had proved its ability in the great war, both at home and abroad.

Engineers should take an active part in public affairs, he asserted. All colonial development of the United States has been dependent on the work of the engineer, but after their labors in establishing lines of communication and transportation improving sanitary conditions and establishing a basis for commercial activity, they have been content to let the remainder of the work be taken over entirely by the administrative forces of the country.

A. Stuart Baldwin, retiring president, gave a masterful address bringing out the need for more coöperative action among the members of the Society.

There must be a more stern and conscientious application of the "Golden Rule," if civilization is to stave off a period of decadence in the future, he said. The engineer must analyze the forces that today are a menace to the peace and prosperity of the world and are directly antagonistic to "Do unto others as ye would have them do unto you."

In beginning his address, Mr. Baldwin said that a development committee had been appointed to study the status of engineers in Chicago and vicinity, and thereafter enter upon a campaign for bringing together the engineers from all branches of the profession, organizing them into one great society and so coördinating their activities as not only to gain professional prestige but to function as a strong and useful member of the body politic. The Society could look forward at no distant date to doubling its present membership.

The next important move should be the construction of an adequate building in Chicago as an engineering center. "With so large a membership," he said, "the work of the directors and executives must to a much greater extent be de-centralized and thrown upon the heads of the Sections, each of which must become to a certain extent a self-contained engineering society, in its own specialty, all coöperating for the common good. If each Section were the working local branch and representative of the national society with which the most of its members were affiliated and if the national societies would father these sections and become their working associates, the Sections would become tremendously strengthened and not only serve to strengthen the Western Society of Engineers, but act as a reservoir from which the national societies would gain strength and inspiration. The national societies all have need for local work on the part of their members. The opportunities for getting together nationally occur but a few times during the year, whereas local sections should be able to meet monthly or even more frequently, if necessary. It will undoubtedly be found that those members of a national society who are able to get together locally most frequently for papers, discussions and consideration of society matters, will be the most influential in the affairs of the national society."

Frederick K. Copeland, Mem.Am.Soc.M.E., the new president, laid down the ambitions of the society for the coming year. Briefly, they are: (1) Increase membership; (2) Organize more sections to aid in professional development of engineer; (3) Pay an important and decisive part in civic affairs; (4) Develop the social activities of the engineer beyond the confines of engineering alone.

"Each and every one of us must show our loyalty and willingness, by giving of our time and our energies, to take part in this great development of the Western Society of Engineers," he concluded.

Mr. Copeland is president of the Sullivan Machinery Co. and for a number of years has been active in the affairs of the Western Society. He was admitted to membership in 1892. In 1919 he was appointed first vice-president to fill the unexpired term of Kempster B. Miller. Besides being active in the affairs of Engineering Council, Mr. Copeland is a director of the National Department of Public Works Association. He is president of the General Committee of Technical Societies of Chicago.

The rapid growth of the Western Society of Engineers has made it necessary that additional facilities as well as space for the administrative force of the organization be obtained. Two additional rooms adjacent to the present quarters of the society on the 17th floor of the Monadnock Building have been obtained and will be available May 1st. The tentative plan is to devote the present quarters to the library, reading rooms, auditorium and committee rooms. The records of the society will be moved to the new quarters as far as will be practicable. Such a move as this will add materially to the advantages to be obtained from the library in that more shelving space will be available, it will be possible to add to the comforts of the reading room and committees may work in rooms in direct contact with the reference files of the society.

H. T. ELLISTON.

SELF-SUPPORTING CHIMNEYS TO WITHSTAND EARTHQUAKES

(*Continued from page* 160)

reinforced-concrete chimney is that given in Turneaure and Maurer's Principles of Reinforced-Concrete Construction, except that the temperature reinforcement was increased materially beyond that indicated in this textbook. The allowed tensile stresses of the reinforcing steel, as well as the compressive stresses in the concrete, due to earthquake, were normal. The temperature stresses alone were slightly above normal for concrete, and less than normal for steel. When these were added to the earthquake stresses, the final result gave a stress safely within the elastic limit for steel, but considerably above what would be considered a safe allowance for the compressive stress of concrete. Investigation of the temperature stresses shows that the above condition is unavoidable, and the conclusion is that while a chimney so designed would not fail by falling during an earthquake, it is easily believable that the combination of earthquake and temperature stresses would result in serious fractures at critical portions of the chimney.

A very important point in the design of such chimneys is the assumption of the difference between the temperature of the gases within the chimney and the temperature of the outer shell of the chimney. Some tests made by the writer indicated that this temperature difference is greater than was assumed in the example given by Turneaure and Maurer, and further data along these lines would be of much interest to designers.

The writer was unable to find any new material of light weight and of low conductivity to be used in lieu of the ordinary concrete or brick lining of a reinforced-concrete chimney; for manifestly it is highly important to minimize the mass of the chimney subject to vibration. It was finally necessary to assume a brick lining. The question then arose as to the height to which this should be carried to minimize temperature stresses in the unlined upper portion of the chimney, which, from experience with earthquakes, is the weakest section of the chimney. It was considered impracticable to carry the chimney lining to this critical section; which indicates a manifest defect of the reinforced-concrete chimney for withstanding earthquakes.

It has recently been suggested to the writer by Mr. C. A. G. Weymouth that in the building of reinforced-concrete chimneys to withstand earthquakes it would be advantageous to use terra-cotta concrete, as developed by the Concrete Ship Section of the Emergency Fleet Corporation. As is well known, terra-cotta concrete materially reduces the weight per cubic foot, and in addition has a high compressive strength. It should be pointed out, however, that any saving in the weight of the chimney shaft, as compared with the ordinary concrete construction, would, of

necessity, be made up by an increase in the weight of the base of the chimney to give the necessary stability against overturning from wind pressure.

The requirement under [7] for the deflection of the chimney shaft should be made with some margin of safety. No data are at present available, but it should be borne in mind that any increased elasticity of the chimney should not be secured at the sacrifice of strength actually necessary to resist moments in the lower portion of the chimney shaft.

It is hardly necessary to state that the chimney designer must give due consideration to the shear produced by earthquake, as well as the shear due to wind pressure; other stresses, however, are usually the determining factors.

It is of course obvious that a chimney to withstand earthquakes should be constructed of materials of maximum strength, of minimum weight, and with maximum elasticity. So far, this combination seems to be best supplied in the use of self-supporting steel chimneys, regardless of whether the conditions of operation require a chimney lining. In California, at least, the earthquake evidence testifies eloquently in favor of the use of steel chimneys.

In closing, the writer will state that while the ultimate solution of the earthquake chimney problem appears impossible in an accurate sense, it is nevertheless to be hoped that some of our engineering physicists will give further study to the rather special questions which it involves.

FIRST TRANSCONTINENTAL MOTOR CONVOY

(*Continued from page* 150)

This was in running through Iowa where the roads were very good. A very different class of troubles developed when running through the western section of the trip as indicated, for example, by what happened during such an average day as August 13.

Departed Rawlins 6:15 a. m. 22 mi. west detour was made around dangerous bridge over dry creek bed. At Creston Station a Class B truck slipped off the road and was helped back by another Class B. Also Class B spare parts truck ran off road on abandoned Union Pacific R. R. grade and was rescued by Militor. Old right-of-way single track most of way and many high, dangerous fills and a number of deep sand holes were encountered. Near Latham Station Class B water tanker No. 80216 ran off road on abandoned railroad grade and rolled over 270°, resting on left side. It was righted by 2 Class B's and proceeded under its own power in 20 min. No serious damage. Class B tank trucks appear to be somewhat top-heavy, and driver claimed that this truck was very hard to steer and almost impossible to keep on road. Trailmobile kitchen broke spring and bent axle. At Wamsutter, F. W. D. No. 415767 stopped to tighten up front universal joint and it was also found to have a broken radiator support stud. Two G. M. C.'s, Garford, Class B and Dodge had carburetor trouble. 3 mi. east of Tipton Station, Class B Machine Shop No. 414,319 ran off road into soft sand hole and had to be towed out by Militor. Right wheels of Mack Blacksmith Shop No. 4 sheared through 16-3" x 10" bridge floor planks, and narrowly averted dropping into 12' ravine. Bridge reinforced and truck rescued in 55 minutes. Six other bridges reinforced by Engineers and it seems that timber in this dry atmosphere loses its elasticity and becomes very brittle. Camped on Red Desert, on barren sandy plain. No inhabitants or buildings other than railroad personnel and property. Nearest natural water supply 16 miles. Fair and warm. Fair dirt roads. Made 58 miles in 10¾ hr. Arrived Tipton Station, Wyo. 5 p. m.

Even that, however, cannot be called the worst and to judge of the troubles that the Convoy had to handle it may be well to read, for example, the log for August 30 to September 1.

Departed Fallon, 6:30 a. m. Followed direct road to Carson City, via the Lahontan Dam. Heavy trucks had some difficulty in getting through soft sand holes about 2 miles out of camp. Five or more trucks were chained together and men not driving helped by pushing. Delay ½ hr. White Reconnaissance Car No. 111505 had to replace spark plug on account of broken porcelain. Required 11 hrs. to move Convoy from Fallon to a point 12 mi. west, on account several stretches of unstable, dry sand up to 1½ ft. deep, and wet quicksand. All heavy vehicles, including Cadillacs had to be pulled and pushed through by combined efforts of tractor and men, over wheel paths made of sage brush. Two Class B tankers sank to a depth of 5 ft. in sand, requiring extensive excavation and construction of false work of railroad ties to aid Tractor in rescue. Dodge Light Delivery No. 26991 broke generator drive chain, damaging oil pump drive. One small bridge broke down. Convoy met by Gov. Boyle, etc. Chicken dinner. Co. E arrived 11 p. m. Fair and warm. Poor gravel roads. Made 66 miles in 20 hrs. Arrived Carson City, Nevada, 2:30 a. m. (31st).

Aug. 31. Carson City, Sunday rest period. Tractor towing Mack with bad clutch, arrived 11:30 a.m after resting on road until daylight. Inspected and adjusted equipment. Changed several tires, pressing done at Reno. Transportation provided and personnel taken to Hot Springs for bathing. Union religious services held at camp on Capitol grounds, at which Governor Boyle made address of welcome. At officers' meeting instructions were given relative to operation precautions to be taken on King's Grade climb tomorrow. Fair and warm.

Sept. 1. Departed Carson City 6:30 a.m. Convoy arranged with heaviest vehicles in lead. Temporary control established at base of King's Grade for inspection of steering gears, brakes, tow chains and wheel blocks, also for spacing vehicles 100 yds. apart. Full supply of gasoline, oil and water verified. Experienced drivers only allowed to drive and one man on each vehicle stood ready to block the wheels at each halt. All passengers required to be on the alert for any emergency. Nevada State Highway Dept. suspended all eastbound traffic from 6:30 a.m. until after Convoy had crossed the Sierras. Motorcycle riders required to maintain vehicle spacing and inspect bearings every 4 miles. Reached altitude of 7630 ft. at summit over narrow, winding road of sand and broken stone, cut out of, and in places built up on, mountain side. Total climb 14 mi. made in 6 hr., slow progress being necessary to prevent accident. Grades 8 to 14 per cent. Crossing Sierras without accident may be considered noteworthy achievement for heavy vehicles. Class B broke fan belt. One Trailmobile kitchen overturned and was wrecked, and was shipped to San Francisco. Mack broke connecting rod, pushing piston through top of the cylinder and cracking crank case, near Glenbrook, where noon "chow" was served and was left there to make emergency repair by cutting out damaged cylinder, piston being welded and cemented in place. At California-Nevada line the War Camp Community Service and Mayor's Comm. of San Francisco gave fine barbecue and enthusiastic welcome. Mr. Celio, owner of Meyer's Ranch, served refreshments in evening around huge camp fire, while the Firestone representatives furnished movies and smokes. Scenery throughout day of greatest beauty, especially at Lake Tahoe. Fair and cool. Fair gravel roads. Made 34 miles in 13½ hrs. Arrived Meyers, Cal., 8 p.m.

On the whole it may be well to repeat what has been said before as to the results, namely, that the pioneer undertaking of its kind, the First Transcontinental Convoy, was a successful operation and the experience gained during this trip will prove invaluable not only to the Army but to all users of motor trucks in general.

ELECTRIC POWER SUPPLY OF SOUTHERN TEXTILE MILLS

(*Continued from page* 161)

Early practice employed large group motors, but comparatively little benefit was derived from their use. The practice now is to use small motors ranging in size from 0.5 hp. on looms to 5 and 7.5 hp. on spinning frames directly applied to the machines. The resulting benefits, principally in production, are a great deal more than sufficient to offset the extra cost for this type of installation. A great many of the old mills, either with mechanical or with large group motor drives, are changing to these individual motor drives. In some departments where it is still customary to use group motors, a number of small units are used, instead of a few large ones. The illustration on page 161 being typical.

Some of the mills so equipped have been in operation for four or five years, and the results justify the expectancy of an increased production, averaging probably 8 per cent, together with a very low maintenance cost. Incidental to the main advantage of increased production, are such minor but well worth while advantages as greater cleanliness, better lighting conditions, and flexibility of operation.

A very strong argument for purchased power is the flexibility it provides for the growth of industrial plants. A plant can be built requiring only a very small amount of power, with the feeling that unlimited extensions can be carried out without fear of power limitation.

The treatment accorded by the power companies to their customers has in general been quite liberal, and the rates have not been increased in line with the increased cost of other commodities.

The illustrations show typical examples of generating plants, distribution lines, substations, and motor installations.